

**pulping and paper-making properties
of
fast-growing plantation wood species**

volume 2

**forestry industries division
forestry department**

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F O R E W O R D

This manual is mainly intended to provide information to tree plantation planners who are interested in the pulping and papermaking characteristics of the species considered for planting. The characteristics vary somewhat with growth conditions and age of the trees and the values given in the data sheets always refer to a specific sample of wood from a specific plantation. The conclusions drawn in the text from the data sheets pertain to these samples. The reader should accordingly bear in mind that samples from plantations with different growth conditions may exhibit differing characteristics, as evidenced repeatedly from the data sheets for some species.

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1. INTRODUCTION

1.1 BACKGROUND INFORMATION

The information presented in this volume is based mainly on available data published between July 1972 and June 1978. In addition, certain references which were not available at the time of preparation of the first volume of this book in 1974 (21) have been included here.

A list of references is given in Appendix I.

1.2 GENERAL INFORMATION ON THE DATA SHEETS

The data sheets give information on one or several samples of wood for each species. In the latter case, the data for each sample are presented separately on the same data sheet for comparison. The basic information given in the data sheets is divided into three main parts:

- a) origin of wood sample including age, when known, and any special conditions;
- b) wood characteristics of sample. This includes basic density, fibre dimensions and chemical characteristics;
- c) pulping and papermaking characteristics of the wood sample. This may include a range of conditions applied in the same process as well as the corresponding range of properties of the pulps and/or different types of processes applied.

In addition to these data sheets which relate to one reference each, an evaluation of each species has been included in the form of a summary based on the information given in the data sheets on that species as well as additional information obtained. Some guidelines are also given as regards experience with respect to plantations and acclimatization of the species in different parts of the world.

The summary for each species shows the references from which the information has been obtained under "Plantation experience" and, in a few cases, under "Pulping characteristics". The references for "Wood characteristics" and the main references for "Pulping characteristics" are given on the relevant data sheets.

The definitions of the terms used are given in Appendix II and a list of the species included is given in Appendix III.

2. INTERPRETATION OF THE DATA SHEETS

2.1 COMPARISON OF PULPING AND PAPERMAKING DATA

Although the determinations of basic density, fibre dimensions and chemical characteristics of wood are fairly straightforward and reasonably well standardised so that values obtained in different laboratories are comparable, this is not so when it comes to determination of the papermaking characteristics of pulps. In spite of the standardisation work which has been carried out in this field, there still remains considerable discrepancy in strength property values. The reason for this is basically that the strength properties of a test sheet of pulp depend, to a great extent, on the treatments given to the pulp before the actual determination of a certain strength value is carried out, as well as on the atmospheric conditions in the room where the determination is made. As regards the latter, three atmospheric conditions are used in the pulp and paper industry; the two most common are 23°C and 50% RH (relative humidity) in Canada and the USA and 20°C and 65% RH in Australia, Europe and New Zealand. In countries like India the conditions are 27°C and 65% RH. In other countries the standards vary with one of the three sets of conditions being used.

As regards the pretreatment of the pulp prior to testing, the factors which affect the results are as follows:

- a) The equipment used for refining and/or beating of the pulp;
- b) The freeness of the pulp after refining and/or beating, expressed either in Canadian Standard Freeness (CSF) or Schopper Riegler (SR) units;
- c) The equipment used for making the sheet of paper for testing;
- d) The extent of pressing of the wet sheet prior to drying and also against what surface the sheet has been pressed;
- e) The way of drying of the sheets and also to what extent shrinkage of the sheet has been allowed or prevented during drying;
- f) The grammage (basis weight) of the sheets used for testing;
- g) The grammage used in the calculation of strength properties (oven-dry or as conditioned);
- h) The type of equipment used for the determination.

Several sets of combinations of these critical factors are in use in different countries and laboratories and this is the main reason for the discrepancy of the results of strength testing.

As regards the actual strength testing, once the conditions for beating and sheet making have been set as well as the atmospheric conditions, there still remains the variation due to different items of equipment for testing, but this is of minor importance in this context.

It is evident from the above that as regards the strength properties given in the data sheets, no direct comparison can be made of the values reported by different sources and consideration has to be given to the influence on the results by the factors mentioned above.

2.3 EVALUATION OF THE PULPING AND PAPERMAKING PROPERTIES

In order to facilitate understanding of the results given in the data sheets, an evaluation has been made of each species in the form of a summary where a general rating is used, with wordings like "under average", "good" and "excellent". These ratings refer only to hardwoods and softwoods separately. The basis for the comparison is an "average" pulp of a commercial grade, from either hardwood or softwood, of whichever type the species may be. Unfortunately, inclusion of reference data for this comparison cannot be given, as they would inevitably lead to misunderstanding due to the reasons given in Section 2.1.

The conclusions arrived at in the evaluation of the results apply only to the samples for which data have been given. It is possible that other wood samples of the same species would lead to other conclusions, due to difference in seed origin, as well as soil and climatic conditions. The age of the tree also exerts an influence on the results.

SUMMARIES AND DATA SHEETS FOR INDIVIDUAL SPECIES

Acacia auriculaeformis

Plantation experience

Indigenous to the islands off the north coast of Australia, this species grows fast on poor soils. It has been used successfully on steep slopes to check soil erosion. The species has been introduced in Tanzania, India, Indonesia and Malaysia. The present sample represents 10 year old trees from a plantation in Papua New Guinea.

References: 21, 22, 56

Wood characteristics

The density of the wood is within the range average to hardwoods. No other data on wood characteristics are given for the present sample.

Pulping characteristics

Sulphate pulping of the wood gives pulp in high yield even when cooked to fairly low residual lignin contents. The good strength values of the unbleached pulp correspond to those of poplar sulphate pulp and the sample exhibits much better characteristics than those of the sample referred to in the previous volume (25).

Scientific name:	Acacia auriculaeformis	Common name:	Papua New Guinea	Reference:	56
Wood sample characteristics					
<u>Wood sample origin:</u> Sample from plantations at Rainyvk, East Sepik District. 10 years old, mixture of three butt logs		<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %			
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 497 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio		Additional information:			
x) 1000 μm = 1mm					

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
 Kappa number
 Yield (unscreened), %
 Screenings, %

Sulphate
 13.0 Na₂O
 17.4
 54.9
 0.2

Brightness

Beater or refiner

Freeness

Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

PFI
 300 CSF
 100 (approx.)
 12 (approx.)

Bleached

Sequence

Chemical consumption, %
 Yield on bleaching, %
 Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

Additional information:

Acacia decurrens (Green Wattle)

Plantation experience

This species is native to south-west Australia, and it is cultivated extensively also in Africa, India and New Zealand because of its bark, which yields a good tanning agent. The present sample, 9 - 14 years old, represents a tree diameter of 200 mm and a tree height of nearly 20 m.

References: 21, 34

Wood characteristics

The medium-dense wood has very short fibres and a very low content of lignin. The extractives content is fairly high.

Pulping characteristics

The wood is easily cooked by the sulphate-process to a Kappa number common for hardwood pulps by application of a reasonable charge of chemicals. The pulp yield is very high in consequence of the low lignin content of the initial wood. The strength of the bleached pulp is in the range normal for poplar sulphate pulp.

Scientific name: <i>Acacia decurrens</i>	Common name: Green wattle Country: New Zealand	References: 34
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Tokoroa district 9-14 years old 5 trees, mean height 19.3 m, mean diam. 227 mm (breast height)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 3.5 Solubility, % in water 4.6 (hot) in 1 % NaOH 19.0 Ash, % Lignin, % 19.7 Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: z) 1000 μm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
15.0 Na₂O (charge)
18.7-21.7
55.9-56.6

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

D EHD
C

Brightness (Elrepho)

89.8-90.8

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Lampen
350 CSF
97
6.6
10.0
428 CSF
90
6.0
9.6

Additional information:

Scientific name: <i>Acacia decurrens</i>	Common name: Country: India	References: 40
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m^3 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 μm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process Sulphate
Chemical consumption, %
Kappa number 20
Yield (unscreened), % 57.4
Screenings, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Bleached

Sequence
Chemical consumption, % Cl 12,9
Yield on bleaching, %
Total yield, %

Brightness

75
Beater or refiner
Freeness
Tensile index, N m/g 54,2
Burst index, kPa m²/g 4,4
Tear index, mN m²/g 6,8

Additional information:

Acacia mollissia
(Black Wattle)

Plantation experience

Indigenous to south-west Australia. It is considered to yield the best tanning agent of all the *Acacia* spp. It has been planted extensively because of its tanbark in Australia, New Zealand, Africa and India. The wood has been widely used in South Africa and Australia. The present sample from New Zealand was taken from 16 year old trees of about 200 mm in diameter.

References: 21, 34

Wood characteristics

This high-density wood contains very short fibres and the lignin content is low.

Pulping characteristics

In accordance with the very low lignin content of the wood, it is easily pulped in the sulphate process and the pulp yield is very high at a low Kappa number. The brightness attained by a four-stage bleaching sequence is extremely high. The strength characteristics resemble those of a beech sulphate pulp.

Scientific name: <i>Acacia mollissima</i>	Common name: Black wattle Country: New Zealand	References: 34
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Tokoroa district 16 years old 5 trees, mean height 19.9 m, mean diam. 218 mm (breast height) <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 593 Fibre length, μ m x) 880 Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 μ m = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 3.3 Solubility, % in water 4.2 (hot) in 1 % NaOH 18.1 Ash, % Lignin, % 18.1 Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process Sulphate
Chemical consumption, % 15 Na₂O (charge)
Kappa number 18.7
Yield (unscreened), % 57.9
Screenings, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

D EHD
°

Brightness (Elrepho)

90.0 -91. 1

Beater or refiner Lampen
Freeness 350 CSF 432 CSF
Tensile index, N m/g 77 61
Burst index, kPa m²/g 4.6 3.2
Tear index, mN m²/g 9.3 8.4

Additional information:

Albissia falcata
(Syn. Albisia falcataria)

Plantation experience

This tree is planted for shade to coffee and tea plantations throughout the Far East. Grows rapidly even in impoverished soil. Diameters up to 170 mm have been obtained at rotations of 3 years. It is grown for pulpwood in Malaysia and in the Philippines.

References: 21, 22

Wood characteristics

The wood density is very low and the fibre length is short to average for hardwoods. No chemical characteristics are given.

Pulping characteristics

The wood is easily cooked by the sulphate process to relatively low Kappa numbers by application of reasonable quantities of chemicals. The unbleached pulp yield is high and it indicates that the initial lignin content of the wood material is low. The pulp strength compares well with poplar and eucalypt sulphate pulps. The loss in strength on bleaching has been considerable, but may be due to the bleaching conditions applied.

<p>Scientific name: <i>Albizia falcataria</i> (<i>Albizzia falcata</i>)</p>	<p>Common name: Moluccan sau Country: Papua New Guinea</p>	<p>Reference: 56</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u> Brown River Forest Station, Port Moresby 7 years old, butt log of one tree</p>	<p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 238 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p>
<p>x) 1000 μm = 1mm</p>		

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Sulphate

13.0 Na₂O

17.9

54.9

0.4

PFI

300 CSF

100 (approx.)

9 (approx.)

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Scientific name: <i>Albisia falcata</i> (L.) Back	Common name: Moluccan sau Country: Philippines	Reference: 70
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 1 100 Fibre length, µm x) 24 Fibre width, µm 3.5 Wall thickness, µm 17 Lumen width, µm 46 Length/width ratio 0.41 Runkel ratio 0.71 Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: Additional information: Ready for harvest at 10 years. Grows rapidly even on impoverished soil. At 3 years: DBH 176 mm and height 16 m. x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
 Kappa number Permanganate no.
 Yield (unscreened), %
 Screenings, %

Sulphate (170°C, sulfidity 25.5%, 15.6% act. alk.)
 88.6 based on chem. charged
 10.9
 53.8
 0.0

Brightness

Beater or refiner

Freeness

Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

Valley
 500
 90.5
 5.45
 7.6

Bleached

Sequence

Chemical consumption, %
 Yield on bleaching, %
 Total yield, %

CEH
 5.5 as Cl-charge
 93.3

Brightness

Beater or refiner

Freeness

Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

77.5
 Valley
 500
 71.0
 3.85
 5.7

Additional information:

Annona sericeae
(Araticum)

Plantation experience

Annona is sparingly represented in Asia and Africa, but it is generously distributed with about 100 species in tropical America, Florida, the West Indies, Mexico, and tropical and subtropical South America. The trees are chiefly valuable for their edible fruits. The growth rate is unknown.

References: 32, 58

Wood characteristics

The basic density of the wood is normal, and the fibres are fairly long for a short hardwood (1.5 mm), relatively broad and have a fairly thick wall.

Pulping characteristics

The sulphate pulp yield obtained is low, probably due to the heavy chemical charge applied. The strength characteristics of the pulp are very good and compare well with eucalypt and birch sulphate pulps.

Scientific name: <i>Amnoma sericeae</i>	Common name: Araticum Country: Brazil	References: 32
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Escola Superior de Florestas in Viscosa, Minas Gerais State <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 550 Fibre length, µm x) 1 530 Fibre width, µm 29.9 Wall thickness, µm 4.8 Lumen width, µm 20.3 Length/width ratio Runkel ratio 0.47 Flexibility ratio 0.68 Additional information: Includes an anatomical description. x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number x)

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate

25.0 Na₂O (charge)

12.1

42.3

0.5

350 CSF

147

7.8

10.3

x) Permanganate Number

Anthocephalus cadamba
(Syn. Anthocephalus chinensis)

Plantation experience

Indigenous to India, Burma and Sri Lanka. This fast growing tree grows on alluvium along rivers. The growth reported in the Philippines is 36 m³/ha.a at a rotation of 3 years. The samples referred to here are from the Philippines, North Borneo and Australia.

References: 14, 19, 21, 22, 41, 70

Wood characteristics

The wood density is medium or low and the fibre length is above average for hardwoods. No data on the lignin content are available, but previous information (25) indicates that the lignin content may be low.

Pulping characteristics

The wood is easily cooked in the sulphate process with a low charge of alkali. The resulting pulp is of average yield with strength characteristics corresponding to those of beech or poplar pulp. The bleaching response is good and the loss of strength during bleaching is minimal. The wood seems to be suitable for NSSC-pulp manufacture.

Scientific name: Anthocephalus cadamba	Common name: Country: North Borneo	References: 14
Wood sample characteristics		
<u>Wood sample origin:</u> Three logs from one tree, 20 years old DH 404 mm over bark <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 370 at breast height Fibre length, µm x) 1 480 Fibre width, µm 38 Wall thickness, µm 5.6 Lumen width, µm 27 Length/width ratio 39 Runkel ratio 0.41 Flexibility ratio 0.71 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 3.3 Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 80.9 Additional information:	At breast height

Pulping and papermaking characteristics

<u>Unbleached</u>	
Process	
Chemical consumption, %	
Kappa number	
Yield (unscreened), %	
Screenings, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, $M \frac{m}{g}$	
Burst index, $kPa \frac{m^2}{g}$	
Tear index, $mN \frac{m^2}{g}$	
<u>Bleached</u>	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, $M \frac{m}{g}$	
Burst index, $kPa \frac{m^2}{g}$	
Tear index, $mN \frac{m^2}{g}$	
Additional information:	

NSC (145°C)
(15 % Na_2SO_3 + 5 % Na_2CO_3 charge)
66.1

Sulphate (170°C)
12.5 act. alkali as Na_2O
50.3
0.5

Valley
590
22.1
0.8
2.5

Valley
560
78.3
4.8
13.2

CEH
3.5 as C1
38.3

80

710
25.0
1.4
6.8

Scientific name: Anthocephalus cadamba	Common name: Country: Philippines	References: 19
Wood sample characteristics		
<u>Wood sample origin:</u> Sample consisted of 8 logs, diameter 145 - 194 mm over bark; Age 7 - 8 a Growth: 9 year old stand had a DBH of 253 mm and a height of 17.6 m <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 370 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.6 Solubility, % in water in 1 % NaOH 17.8 Ash, % 1.0 Lignin, % Holocellulose, % 66.0 Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Prehydrolysis-sulphate (170°C)

11.3 act. alkali as Na₂O

21.2

32.8

0.0

88.2 α-cellulose, %

CEDED

7.9 added as Cl

88.8

29.2

24.4 viscosity, cp (bleached)
96.0 α-cellulose, %

Scientific name: Anthocephalus cadamba (Rob.) Miq.	Common name: Philippine wonder tree Country: Australia	Reference: 41
Wood sample characteristics		
<u>Wood sample origin:</u> Humpty Doo, Darwin, N. Australia 2.5 year old trees from wind row planting Diameters (db) 14 - 20 cm Heights 8.6 - 10.2 m Butt, middle and top logs of 8 trees <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 332 Fibre length, µm x) 1 230 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: 39% bark (by volume) of logs x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
14 (charge)
20.0
46.5
0.5

NSSC
15-25 % Na_2CO_3 + 3.5-5.8 % Na_2CO_3
124-87 (charge)
69-57
0

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

203 mm Bauer lab. refiner
300 CSF
70-80
- 8

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
5.3 (% in CandH)
92.5
42.6

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

91.3 % Elrepho
PFI
300 CSF
70
- 9.5

Additional information:

sulphidity 25%, 2 h at max. temp. 170°C 2-3 at max. temp. 170-180°C

Scientific name: Anthocephalus cadamba	Common name: Kaatoan bangkal Country: Philippines	Reference: 70
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 1 390 Fibre length, µm x) 33 Fibre width, µm 4 Wall thickness, µm 25 Lumen width, µm 42 Length/width ratio 0.32 Runkel ratio 0.76 Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: "Miracle tree". Fast-growing. Height at 3 years 8-11 m. DBH 270 mm. Growth 36 m ³ /ha.a x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate (170°C, 25.5% sulfidity, 15.6% act. alkali)

87.3 based on chem. charged

22

47.5

0.2

Valley

500

114.5

5.7

8.0

CEH

6.6 as Cl-charge

90.5

77.0

Valley

500

85.0

3.5

5.2

Aquilaria agallocha
(Agarwood)

Plantation experience

Agarwood or Eaglewood is the only timber tree of the Thymelaeaceae family. It is found in the Indo-Malayan region, particularly Assam. No data on growth rates are available.

References: 33, 58

Wood characteristics

The fibre length and the lignin content are about average for hardwoods. The content of extractives soluble in ethanol-benzene is comparatively high. The wood density is not given for the present sample.

Pulping characteristics

At a relatively high Kappa number (29) the sulphate pulp yield obtained is still comparatively low for a hardwood. The strength characteristics of the unbleached pulp correspond roughly to those of beech pulp. The sample exhibits a considerable decrease in strength on bleaching, but this may well be caused by the apparently very severe bleaching conditions applied.

Scientific name: <i>Aquilaria agallocha</i> Roxb.	Common name: Agarwood Country: India	References: 33
Wood sample characteristics		
<u>Wood sample origin:</u> Mariani Range Shibsagar Forest Division, Assam, India	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 4.5 Solubility, % in water in 1 % NaOH 10.9 (hot) 17.1 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 0.7 21.8 72.4 16.1	Additional information: x) 1000 μ m = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio 1 050 17 62	Additional information: x) 1000 μ m = 1mm	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
14 (charge)
29.0
49.2
00.5

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Lampen
250 (?)
73
4.7
8.3

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEH
14.5% Cl (tot. charge)
45.9

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Lampen
250
59
4.6
6.3

Additional information:

Araucaria angustifolia
(Parana Pine, Brazilian Pine)

Plantation experience

Native of Brazil, where it has been planted as well as in Argentina, Australia and East and South Africa. The growth increment is classified as low.

References: 21

Wood characteristics

This medium density wood has very long fibres, about 5 mm on the average. The fibre width is also remarkable. The lignin content is within the normal range for softwoods.

Pulping characteristics

The chemical charge required in sulphate pulping is fairly high, and the pulp yield obtained is considered high in comparison with the relatively high lignin content. Due to the long fibres the tear strength is exceptionally high. The tensile strength is quite low, obviously a result of the thick-walled fibres that do not provide adequate fibre bonding. For further information see reference 25.

<p>Scientific name: <i>Araucaria anquistifolia</i></p>	<p>Common name:</p> <p>Country: Brazil</p>	<p>References: 26</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p>natural forest</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, %</p> <p>Ether</p> <p>Methanol</p> <p>Ethanol-benzene</p> <p>2.2</p> <p>Solubility, %</p> <p>in water</p> <p>in 1 % NaOH</p> <p>1.4</p> <p>7.3</p> <p>Ash, %</p> <p>Lignin, %</p> <p>Holocellulose, %</p> <p>Cross-Bevan cellulose, %</p> <p>Pentosans, %</p> <p>0.3</p> <p>29.3</p> <p>53.4</p> <p>7.2</p> <p>Additional information:</p>	<p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³</p> <p>420</p> <p>Fibre length, µm x)</p> <p>5 150</p> <p>Fibre width, µm</p> <p>47.11</p> <p>Wall thickness, µm</p> <p>6.44</p> <p>Lumen width, µm</p> <p>34.22</p> <p>Length/width ratio</p> <p>109</p> <p>Runkel ratio</p> <p>0.37</p> <p>Flexibility ratio</p> <p>0.73</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°C)
20
26.5
51.1
0.3

Brightness

Beater or refiner

Jokro

Freeness

x)

Tensile index, N m/g

58.61

Burst index, kPa m²/g

3.89

Tear index, mN m²/g

17.0

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

x) at 600 g/cm³ apparent density

Bursera simaruba
(Gum Elemi)

Plantation experience

It is widely distributed in tropical and subtropical America. Growth is indicated to be 25 m³/ha.a or in the medium class. No details are available. The particular sample referred to here is taken from a natural forest in Belize.

References: 48, 58

Wood characteristics

This wood of low to medium density contains short fibres and a lignin content in the normal range for hardwoods.

Pulping characteristics

The wood is not easily cooked in the sulphate process at 170°C, judging from the relatively high Kappa number of the resulting pulp. The pulp yield is comparatively low for a hardwood, especially in view of the high Kappa number. The strength characteristics of the pulp correspond to those of beech pulp.

Scientific name: <i>Bursera sinaruba</i>	Common name:	References: 48
	Country: Belize	
Wood sample characteristics		
<u>Wood sample origin:</u> From natural forests at Melinda Age probably 8 - 9 years Five trees sampled: diameter 255 mm Growth 25 m ³ /ha • a <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 347 Fibre length, µm x) 820 Fibre width, µm 29 Wall thickness, µm 3.1 Lumen width, µm 23 Length/width ratio 28 Runkel ratio 0.27 Flexibility ratio 0.79 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.1 Solubility, % in water in 1 % NaOH 18.3 Ash, % 1.4 Lignin, % 20.5 Holoellulose, % 71.3 Cross-Bevan cellulose, % Pentosans, %	Additional information:

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°C)
13.7 act. alkali as Na₂O
26.3
49.0
0.1

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
500
72
4.6
7.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
9.6 as Cl
46.1

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

84
PFI
500
70
4.3
6.8

Additional information:

Cedrus atlantica
(Atlantic Cedar, Atlas Cedar)

Plantation experience

The genus is of European and Asian origin. This 14 year old wood sample is from an experimental plantation in Italy. No data on growth increment are available.

References: 13, 67

Wood characteristics

The sample is of medium density and contains fibres which are very short for a softwood. The lignin content of the wood is in the normal range for softwoods.

Pulping characteristics

The sulphate pulp yield obtained after cooking at 175°C is very low. The strength characteristics are not of such level expected from a softwood pulp. Bleaching by application of the sequence CEHEH did not give a pulp of acceptable brightness.

According to the evaluation of the present sample, the species is considered unsuitable for chemical pulping.

Scientific name: Cedrus atlantica	Common name: Country: Italy	Reference: 13
Wood sample characteristics		
<u>Wood sample origin:</u> From a center near Rome Mean annual temperature 15°C Mean annual precipitation 780 mm Age 14 a Usable height 11 m <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 412 Fibre length, µm x) 2 200 Fibre width, µm 28 Wall thickness, µm 4.5 Lumen width, µm 19 Length/width ratio 79 Runkel ratio 0.48 Flexibility ratio 0.68 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % 1.3 Ether Methanol Ethanol-benzene 5.0 Solubility, % in water in 1 % NaOH Ash, % 0.4 Lignin, % 28.7 Hemicellulose, % 66.1 Cross-Beyan cellulose, % Pentosans, % Additional information: Hemicellulose, % 28.2	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (175°C)

18 charge of active alkali
35
40

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI

32 SR
86
6.2
10.1

Bleached

Sequence

Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHEH

10 charged as C1

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

68 GE

Additional information:

Cupressus lusitanica
(Mexican Cypress)

Plantation experience

The species is indigenous to Central America, but it has long been cultivated in Europe. It has been introduced in Australia and East Africa.

References: 3, 21

Wood characteristics

The medium-dense wood from trees 7 or 7 - 15 years old contains fibres which are short for a softwood. The lignin content is not given, but the holocellulose content is 63 - 70% which indicates that the lignin content is medium or high.

Pulping characteristics

The sulphate pulps cooked to 60 - 70% yield exhibit strength characteristics which can be considered good, although not exceptionally so, for softwood high-yield pulp.

Scientific name: Cupressus lusitanica	Common name:	Reference: 3
	Country: Kenya	
Wood sample characteristics		
<u>Wood sample origins:</u> Plantation-grown Under 7 a and 7-15 a logs	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	370 1 870 37 dia. 4.6 28 51 63.5 1.35
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, μ m x) Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio	Additional information:	Additional information:
x) 1000 μ m = 1mm		

Pulping and papermaking characteristics

Unbleached

Process Chemical consumption, % x)

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information: x) Act. alkali

7-15 a
Sulphate

7.2

70.2

2.2

Valley

440

59.8

4.3

9.8

< 7 a
Sulphate

7.2

61.2

1.0

Valley

450

63.7

4.9

8.3

Eucalyptus alba

Plantation experience

This is one of the principal species of eucalyptus planted in Brazil for use in the pulp industry.

References: 22

Wood characteristics

The basic density of the wood is in the medium to high range of hardwoods used for pulping. The fibres are of short length, wide and the cell walls are slightly on the thick side. Nevertheless, the fibres are not too stiff (flexibility ratio ≈ 0.50). The chemical characteristics do not reveal anything that might cause difficulties in chemical pulping.

Pulping characteristics

The yields on sulphate pulping are low to average for eucalypts, with normal alkali charges. The pulp strengths are about normal for eucalypt sulphate pulps.

Scientific name: Eucalyptus alba (syn. E. urophylla)	Common name: Country: Brazil	Reference: 8
Wood sample characteristics		
<u>Wood sample origin:</u> a) 5 years old b) 7 years old	<u>Density and fibre characteristics:</u> Basic density, kg/m ³ a) 532 - 556 b) 575 Fibre length, μ m x) Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Bunkal ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %
Additional information: x) 1000 μ m = 1mm	Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate

21

54.0 - 56.0

45 SR

102 - 111

6.5 - 7.2

12.2 - 13.0

Scientific name: Eucalyptus alba (syn. E urophylla)	Common name: Country: Brazil	Reference: 9
Wood sample characteristics		
<u>Wood sample origins:</u> Sample from the plantations in the region of Linhares 4 years old (average) <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 468 Fibre length, µm x) 890 Fibre width, µm 19.5 Wall thickness, µm 4.8 Lumen width, µm 9.8 Length/width ratio 46 Runkel ratio 0.98 Flexibility ratio 0.50 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.6 Solubility, % in water 2.2 (hot) in 1 % NaOH 17.0 Ash, % 0.4 Lignin, % 23.9 Holocellulose, % Cross-Bévan cellulose, % 53.4 Pentosans, % 18.8 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number x
Yield (unscreened), %
Screenings, %

Brightness xx

Sulphate
14.0 Na₂O
11.0
50.1
0.1
42.2

Sulphate
12.0 Na₂O
16.0
51.1
0.2
31.0

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
30 SR 45 SR 60 SR
87 95 98
5.4 6.3 6.7
9.0 8.3 9.4

30 SR 45 SR 60 SR
85 99 102
5.2 6.1 6.6
8.6 9.2 9.5

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

CEHDED
93.6
46.8

CEHDED
93.5
47.6

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
30 SR 45 SR 60 SR
82 88 91
4.6 5.1 5.3
8.5 8.2 8.0

30 SR 45 SR 60 SR
75 82 86
4.5 4.7 4.9
9.5 9.1 9.0

Additional information:

x Permanganate number (ABCP CA/71)
xx ABCP P16/73

Eucalyptus calophylla

Plantation experience

No information available.

Wood characteristics

The basic density of the wood is somewhat high compared to hardwoods normally used for pulping. The fibres are longer than average for hardwoods.

Pulping characteristics

The yield on sulphate and NSSC pulping are relatively high and the pulps obtained exhibit good strength characteristics although somewhat inferior to normal eucalypt pulps. Reasonable results are also obtained by means of the chemi-thermomechanical pulping (CTMP) process.

<p>Scientific name: <i>Eucalyptus calophylla</i></p>	<p>Common name:</p> <p>Country: Australia</p>	<p>References: 36</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, %</p> <p> Ether</p> <p> Methanol</p> <p> Ethanol-benzene</p> <p>Solubility, %</p> <p> in water</p> <p> in 1 % NaOH</p> <p>Ash, %</p> <p>Lignin, %</p> <p>Holocellulose, %</p> <p>Cross-Bevan cellulose, %</p> <p>Pentosans, %</p> <p>Additional information:</p>	
<p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ 618</p> <p>Fibre length, µm x)</p> <p>Fibre width, µm</p> <p>Wall thickness, µm</p> <p>Lumen width, µm</p> <p>Length/width ratio</p> <p>Runkel ratio</p> <p>Flexibility ratio</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

CTMP
X

85.3

86.7

Brightness

36.2

37.0

Beater or refiner

Bauer

Freeness
Tensile index, M m/g
Burst index, kPa m²/g
Tear index, mN m²/g

54 CSF
38

104 CSF
22

5.7

4.6

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner

Freeness
Tensile index, M m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

X Solution containing 1.6% NaOH and 1.25% Na₂SO₃
Liquor: wood ratio 5:1

Scientific name: <i>Eucalyptus calophylla</i>	Common name: Australia Country:	References: 55
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Pemberton and the Pimelia district 26 - 30 year old thinnings	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bavan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 607 Fibre length, µm x) 1 330 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
14.0 Na₂O (charge) x
24.1
54.4
NSSC
x
72.5

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Lampen
338 CSF
82
5.5
11.8
Lampen
374 CSF
45
2.0
5.8
267 CSF
57
2.9
7.9

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

x 14 % Na₂SO₃ + 6 % NaHCO₃ (charge)
x 18 % Na₂SO₃ + 6 % NaHCO₃ (")

Eucalyptus camaldulensis

Plantation experience

This is the most widely used eucalypt species in plantations together with E. globulus. The most successful plantations are in Spain, Portugal and North Africa. Good results have also been obtained in Turkey, Sri Lanka, Kenya, Rhodesia, Malawi, the Republic of South Africa, California, Florida, Brazil, Argentina and Chile. The species is very adaptable to climate and soil. A more detailed review and a list of references are given in the previous volume.

References: 21, 30

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping. The fibres are relatively short, even for hardwoods, thin and of average wall thickness. Thus, the pulp made from this species should exhibit good opacity. The lignin content of the sample from Brazil is very high for a hardwood and may have an effect on the yield of chemical pulping.

Pulping characteristics

Relatively low alkali charges give low to medium yields in sulphate pulping. The strength properties are about the average for eucalypt pulp. The pulps are readily bleached and results on mill scale pulping correspond to the results obtained in laboratory tests.

NSSC pulping gives high yields and the pulps have excellent strength properties.

Scientific name: <i>Eucalyptus camaldulensis</i>	Common name: Country: Brazil	Reference: 9
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in the region of Linhares 4 years old (average)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.9 Solubility, % in water in 1 % NaOH 1.7 (hot) Ash, % Lignin, % Holocellulose, % Gross-Bevan cellulose, % Pentosans, % 0.8 29.3 50.0 17.2	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio 440 780 15.2 4.0 7.1 51 1.13 0.47	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	14.0 Na ₂ O	12.0 Na ₂ O
Kappa number	11.3	18.5
Yield (unscreened), %	46.9	52.2
Screenings, %	0.1	3.3
Brightness xx	40.5	34.3
Beater or refiner	Jokro	
Freeness	30 SR	45 SR
Tensile index, N m/g	79	86
Burst index, kPa m ² /g	4.9	6.0
Tear index, mN m ² /g	11.0	9.7
		60 SR
		78
		93
		101
		10.5
		8.0
		10.0

Bleached

Sequence	CEHDED	CEHDED
Chemical consumption, %	95.3	89.1
Yield on bleaching, %	44.6	43.6
Total yield, %		
Brightness xx	87.0	88.5
Beater or refiner	Jokro	
Freeness	30 SR	45 SR
Tensile index, N m/g	76	77
Burst index, kPa m ² /g	4.4	4.5
Tear index, mN m ² /g	8.8	9.0
		60 SR
		82
		85
		10.6
		5.6
		5.4
		10.0

Additional information: x Permanganate Number (ABCP CA/71)

xx ABCP P16/73

Scientific name: <i>Eucalyptus camaldulensis</i>	Common name:	Reference: 30
	Country: USA	
Wood sample characteristics		
<u>Wood sample origin:</u> Florida 10 years old (approximately)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 529 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio		Additional information: x) 1000 μm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number ml
Yield (unscreened), %
Screenings, %

NSSC Sulphate^x

38 12
74 (screened) 45

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

400 CSF
72
4.5

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

300 CSF

7.0
9.3

Additional information:

x Mill scale

Eucalyptus citriodora

Plantation experience

The species has been planted in Portugal, North Africa and Sri Lanka mainly as an ornamental tree. Good results have been obtained in South, West, Central and East Africa and Brasil, whereas it has failed to acclimatize in Kampuchea, India and Indonesia. The species is relatively adaptable. For detailed information and a list of references see the previous volume (21).

Wood characteristics

The wood is of relatively high density. It is also very hard and difficult to debark. The fibre length is about normal for hardwoods used for pulping. The fibres are thin and thick-walled, which may cause undesirable stiffness and lack of proper inter-fibre bonding in the paper. The lignin content is low, which implies ease of chemical pulping. The extractives content is on the other hand slightly on the high side for a hardwood.

Pulping characteristics

The alkali consumption in the sulphate process seems to be low. Yields are slightly below average for a hardwood. The strength properties of the pulps, except the tear index, are not up to the standards of good quality eucalypt sulphate pulps.

Scientific name: Eucalyptus citrodora	Common name:	Reference: 29
	Country: Brazil	
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in "Estado de Minas Gerais" 7 and 13 years old	<u>Chemical characteristics:</u> Extractives, % Ether 2.7 - 2.9 Methanol 4.1 - 4.5 (hot) Ethanol-benzene 16.9 - 19.3 Solubility, % in water 0.21 - 0.34 in 1 % NaOH 15.3 - 17.8 Ash, % 56.7 - 61.5 Lignin, % 18.1 - 23.5 Holocellulose, % Cross-Beyan cellulose, % Pentosans, %	
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 637 - 738 Fibre length, μ m x) 915 - 943 Fibre width, μ m 15.5 - 15.9 Wall thickness, μ m 5.4 - 5.7 Lumen width, μ m 4.4 - 4.8 Length/width ratio 59 Runkel ratio 2.3 - 2.6 Flexibility ratio 0.28 - 0.31	Additional information:	Additional information:
x) 1000 μ m - 1mm		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate

13 - 13.25 Na₂O %
47.8 - 49.2
3.2 - 4.8

Brightness

Beater or refiner
Freeness
Tensile index, M m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro

30 SR 45 SR 60 SR
72 - 77 83 - 84 87 - 90
3.8 - 4.8 5.3 - 5.8 6.0 - 6.5
11.1 - 15.3 13.5 - 15.0 13.9 - 14.4

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, M m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

Charge to permanganate number 16.0 ± 1.0

Eucalyptus cloeziana

Plantation experience

Good results have been achieved in Brazil and Congo. Yet, sufficient experience has not been gained with the species. Profitable use is to be expected because of its rapid growth in relatively dry tropical climates. For additional references see the previous volume (21).

References: 9, 21

Wood characteristics

The basic density of the wood is in the range normal for pulpwood. The fibres are of average length and width for hardwoods, but thick-walled, which suggests a certain amount undesirable stiffness and lack of proper interfibre bonding in paper. The lignin content is high and may cause difficulties in chemical pulping.

Pulping characteristics

Sulphate pulp yields of about 50 percent are obtained with relatively low alkali charges. The strength properties of the pulps obtained are, however, not up to the standards of average eucalypt pulp.

Scientific name: <i>Eucalyptus cloesiana</i>	Common name: Country: Brazil	Reference: 9
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in the region of Linhares 4 years old (average)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.6 Solubility, % in water 2.3 (hot) in 1 % NaOH 11.8 Ash, % 0.3 Lignin, % 28.3 Holocellulose, % Cross-Beman cellulose, % 53.8 Pentosans, % 15.5	Additional information: x) 1000 μ m = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 529 Fibre length, μ m x) 860 Fibre width, μ m 18.0 Wall thickness, μ m 5.3 Lumen width, μ m 7.4 Length/width ratio 47 Runkel ratio 1.43 Flexibility ratio 0.41	Additional information:	

- Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	14.0 Na ₂ O	12.0 Na ₂ O
Kappa number ^x	11.2	17.9
Yield (unscreened), %	50.1	52.4
Screenings, %	0.1	1.0
Brightness ^{xx}	39.4	32.5
Beater or refiner	Jokro	
Freemess	30 SR	30 SR
Tensile index, N m/g	73	70
Burst index, kPa m ² /g	4.1	4.1
Tear index, mN m ² /g	8.2	8.5
	45 SR	45 SR
	80	76
	4.7	4.7
	10.1	9.2
	8.3	5.0
		9.5
	60 SR	60 SR
	84	80

Bleached

Sequence	CEHDED	CEHDED
Chemical consumption, %	94.8	91.8
Yield on bleaching, %	47.4	47.2
Total yield, %		
Brightness ^{xx}	86.4	89.0
Beater or refiner	Jokro	
Freemess	30 SR	30 SR
Tensile index, N m/g	57	78
Burst index, kPa m ² /g	2.6	4.4
Tear index, mN m ² /g	7.4	8.4
	45 SR	45 SR
	66	83
	3.3	4.8
	8.3	8.7
	8.8	9.0
	60 SR	60 SR
	70	86

Additional information: ^x Permanganate Number (ABCP C4/71)

^{xx} ABCP P16/73

Eucalyptus cypellocarpa

Plantation experience

A species previously considered unsuitable, but nowadays accepted for pulping in New South Wales and Victoria, Australia. No references on the plantation experience of the species are available.

Wood characteristics

The basic density is around the upper limit for hardwoods used for pulping. No data on the fibre or chemical characteristics are available for the present sample.

Pulping characteristics

The yield of the sulphate pulp with a normal alkali charge is low for a hardwood. The strength properties are acceptable for many purposes though below average for good quality eucalypt pulp.

<p>Scientific name: <i>Eucalyptus cypellocarpa</i></p>	<p>Common name:</p> <p>Country: Australia</p>	<p>References: 71</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p>a) 25 years old</p> <p>b) 25 - 30 years old</p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ a) 576 b) 655</p> <p>Fibre length, µm x)</p> <p>Fibre width, µm</p> <p>Wall thickness, µm</p> <p>Lumen width, µm</p> <p>Length/width ratio</p> <p>Runkel ratio</p> <p>Flexibility ratio</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, %</p> <p>Ether</p> <p>Methanol</p> <p>Ethanol-benzene</p> <p>Solubility, %</p> <p>in water</p> <p>in 1 % NaOH</p> <p>Ash, %</p> <p>Lignin, %</p> <p>Holocellulose, %</p> <p>Cross-Bevan cellulose, %</p> <p>Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Sulphate

14.0 - 17.0 Na₂O (charge)

23.1 - 13.2

48.4 - 46.6

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

PFI

350 CSF

70 (approx.)

10.5 (approx.)

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Eucalyptus deanei

Plantation experience

No information available.

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping and the fibre length is about the average for hardwoods. The lignin content is high for hardwoods.

Pulping characteristics

A high alkali charge seems to be required to delignify the wood to a Kappa number which is normal for hardwood pulps and the yield of pulping is low for a hardwood. The strength characteristics of the pulp is slightly below the average for commercial eucalypt pulps.

Scientific name: Eucalyptus deanei	Common name: Country: Brazil	References: 8
Wood sample characteristics		
<u>Wood sample origin:</u> 7 years old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 513 Fibre length, µm x) 950 Fibre width, µm 18.0 Wall thickness, µm 4.5 Lumen width, µm 9.0 Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.4 Solubility, % in water in 1 % NaOH 1.6 (hot) Ash, % 0.4 Lignin, % 26.8 Holocellulose, % Cross-Bevan cellulose, % 53.8 Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number x

Yield (unscreened), %

Screenings, %

Sulphate

15.1

51.2

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

34 SR

86

7.3

14.7

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information: x

Permanganate number

Scientific name: Eucalyptus deanei	Common name:	Reference: 43
	Country: Argentina	
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from "la Estacion Experimental castelar del Ministerio de Agricultura"	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water 0.3 - 2.5 in 1 % NaOH 14.3 - 17.2 Ash, % 23.4 - 30.1 Lignin, % Holo cellulose, % Cross-Bevan cellulose, % Pentosans, %	1.7 - 4.6 (hot)
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 462 - 576 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio		
Additional information:	Additional information:	
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
17.5 - 19.5 NaOH
17.0 - 23.0
45.1 - 49.2
0.7 - 1.0

Sulphate
15.3 - 19.8 NaOH
22
44.9 - 50.2
0.7 - 3.2

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Valley
40 SR
86 - 102
4.8 - 6.1
7.9 - 9.3

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEH
CEHEH
CEHEH

Brightness (Tappi)

67.5 - 72.5
81.9 - 84.6
86.7 - 87.5

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Valley
40 SR
89 - 100
5.7 - 6.8
7.6 - 10.2

40 SR
93 - 104
5.9 - 7.0
8.0 - 10.1

Additional information:

x charge

Eucalyptus deglupta
(Mindanao Gum Kamarere)

Plantation experience

The species is indigenous to the Philippines, the Celebes, New Guinea, New Britain and New Ireland. Good results have been reported from Brasil, Sri Lanka, Cuba, India, Java, Malaysia, North Borneo and the Solomon Islands. It is fast-growing and has acclimatized well in tropical island climates.

References: 21, 22

Wood characteristics

The basic density is on the low side for hardwoods used for pulping.

Pulping characteristics

Sulphate pulping requires relatively low alkali charges and the yield in the kappa number 20 is about 50 percent. The strength properties of the pulp do not seem to reach the standards of good quality eucalyptus pulp. Bleached pulps of high brightness can be produced in satisfactory yields using the CEHD sequence.

Reasonable results, although inferior to those of E. regnans, have been obtained in chemi-thermomechanical pulping (CTMP).

Scientific name: <i>Eucalyptus deglupta</i>	Common name: Country: Australia	References: 36
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m^3 307 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
Additional information: x) 1000 μm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, % x

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

x Solution containing 1.6% NaOH and 1.25% Na₂SO₃
Liquor: wood ratio 5:1

CTMP

85.3

87.8

32.0

Bauer

372 CSF

21

277 CSF

30

3.8

4.3

<p>Scientific name: <i>Eucalyptus deglupta</i></p>	<p>Common name: Kamarere Country: Papua New Guinea</p>	<p>References: 56</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u> Samples from plantations at Keravat, New Britain 6 - 13 years old</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p>	<p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 313 - 423 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p>
<p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 313 - 423 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p>	<p>Additional information:</p>	<p>Additional information:</p>
<p>x) 1000 µm = 1mm</p>		

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
 Kappa number
 Yield (unscreened), %
 Screenings, %

Sulphate

12.5 - 13.5 Na₂O (charge)
 19.0 - 19.5
 49.7 - 50.1
 0.4 - 0.7

Brightness

Beater or refiner

Freeness
 Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

PFI

300 CSF
 60 - 80 (approx.)
 9.5 - 12.0 (approx.)

Bleached

Sequence

Chemical consumption, %
 Yield on bleaching, %
 Total yield, %

CEHD

2.7 - 2.9 Cl₂
 93.5 - 96.5
 45.7 - 46.9

Brightness

Beater or refiner

Freeness
 Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

86.4 - 89.4

Additional information:

Eucalyptus diversicolor

Plantation experience

The species occurs in considerable quantity in Western Australia. Typically, the tree reaches a height of 45 m and a girth of 5 m with good wood quality. Trees up to 87 m in height with diameters of 2 - 2.5 m have been measured. No data on cultivation of the species are available.

References: 55

Wood characteristics

The basic density is around the upper limit for hardwoods used for pulping. The fibres are longer than average for hardwoods.

Pulping characteristics

Pulps of low kappa number are obtained with normal alkali charges in the sulphate process. The yield is very high. The strength properties, with the exception of the tear index, are not comparable to the standards of good quality eucalypt pulp.

Application of the NSSC process gives pulps of good strength properties.

Reasonable results on chemi-thermomechanical pulping (CTMP) have been reported.

Scientific name: <i>Eucalyptus diversicolor</i>	Common name:	Reference: 36
	Country: Australia	
Wood sample characteristics		
<u>Wood sample origin:</u> Samples from Pemberton and the Pinellia district 26 - 30 year old thinnings	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 644 Fibre length, μm x) 1 320 Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 μm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
14.0 Na₂O (charge)
12.3
56.2

NSSC
x
73.4

NSSC
xx
72.9

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Lampen
388 CSF
76
4.4
11.5

Lampen
264 CSF
56
2.8
7.4

322 CSF
43
1.8
6.2

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

x 14% Na₂SO₃ + 6% NaHCO₃ (charge)
xx 18% Na₂SO₃ + 6% NaHCO₃ (charge)

Additional information:

Scientific name: <i>Eucalyptus diversicolor</i>	Common name: Country: Australia	Reference: 55
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 561 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

CTMP
x
88.8
86.0

Brightness

20.9
20.8

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Bauer
127 CSF
24
4.6

59 CSF
37
5.3

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

Solution containing 1.6% NaOH and 1.25% Na₂SO₃
Liquor: wood ratio 5:1

Eucalyptus dunnii

Plantation experience

No information available.

Wood characteristics

The basic density and the fibre length are in the average range for hardwoods used for pulping. The data on other fibre dimensions indicate a certain amount of stiffness, which may affect the potential bonding in paper. The chemical characteristics do not indicate any difficulties on chemical pulping.

Pulping characteristics

The yield on sulphate pulping is good and the pulp obtained exhibits strength characteristics typical of a good eucalypt pulp; the tear index is exceptionally high but may be due to the sample being from a young tree.

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Sulphate

17

53.7

33

57.5

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

35 SR

82

6.9

17.1

40 SR

92

7.8

15.7

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Eucalyptus fastigata

Plantation experience

No information available.

Wood characteristics

The basic density is relatively low for hardwood pulpwood and the fibres are shorter than average.

Pulping characteristics

The sulphate process gives pulp in high yield at a normal Kappa number level using comparatively short cooking times. The pulps are easily bleached to high brightness and the strength characteristics are representative of average quality eucalypt pulp.

Scientific name: <i>Eucalyptus fastigata</i>	Common name: Country: New Zealand	Reference: 34
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Tokoroa district 6 years old 15 trees, mean height 10.7 mean diam. 180 mm (breast height)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.3 Solubility, % in water in 1 % NaOH 15.4 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 380 Fibre length, µm x) 850 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Sulphate

15.5 - 18.0 Na₂O (charge)

28.9 - 17.4

55.2 - 52.5

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

D_{EHD}
C

Brightness

90.5 - 92.8

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Lampen

350 CSF

93

6.8

9.3

432 CSF

84

6.6

9.4

Additional information:

Eucalyptus globulus
(Blue Gum)

Plantation experience

This is the most widely planted eucalypt species. The species grows best on deep soils free of carbonates in mild climates with uniform rainfall or with winter or summer maximum. The annual yields per ha are excellent. For a list of references see the previous volume (21).

Wood characteristics

The basic density of the wood is within the range normal for hardwoods used for pulping. The fibres are of low to average length and width for hardwoods, and thin walled, which suggests desirable flexibility and good inter-fibre bonding in paper. The lignin content is relatively low. The data on the Mexican samples differ from the others both in fibre and chemical characteristics.

Pulping characteristics

High yields are obtained in the sulphate process with relatively low alkali charges to produce pulps of the kappa number of 20. The strength properties of the pulps are very good and the pulps are readily bleached to high brightness levels.

Application of the NSSC process gives pulps of very good strength. The pulps have been bleached up to the brightness of about 80, but the overall yield has then dropped to 50 percent. Magnesium bisulphite pulping in the semi-chemical-chemical range yields pulps of just acceptable strength properties.

Cold soda pulping yields good quality pulp. Pulping with bark present has no significant deleterious effect on the strength properties. The brightness obtained was lower, but acceptable levels are attained when bleaching with 2 percent available chlorine.

Scientific name: <i>Eucalyptus globulus</i>	Common name: Country: Brazil	References: 10
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Salesopolis - Sao Paulo 3.5 years old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 479 Fibre length, µm x) 1 030 Fibre width, µm 17.3 Wall thickness, µm 3.4 Lumen width, µm 10.6 Length/width ratio 60 Runkel ratio 0.641 Flexibility ratio 0.61 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number x
Yield (unscreened), %
Screenings, %

Sulphate
13.0 Na₂O (charge)
20.1
55.3
11.8

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
30 SR
105
8.1
12.9

83 SR
115
9.3
10.1

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information: x Permanganate Number

Scientific name: <i>Eucalyptus globulus</i>	Common name: Country: Australia	References: 23
Wood sample characteristics		
<u>Wood sample origin:</u> a) 4 - 6 years old stemwood b) 4 - 6 years old stemwood (fertilized) c) whole tree 6 years old (fertilized)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water x in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	a) 3.1 - 6.0 a) 18 - 21 a) 17 - 19 a) 22 b) 4.0 - 5.2 b) 17 - 20 b) 17 b) 21 - 22 Additional information: x boiling	
Additional information: x) 1000 µm = 1mm		

Scientific name: Eucalyptus globulus	Common name: Country: Mexico	Reference: 59
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Eucalyptus Plantations of de la Escuela Nacional de Agricultura de Chapingo, Estado de Mexico 12 years old	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 4.7 4.9 16.2 0.6 21.8 74.4 16.7 cellulose % 42.4
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	 580 760 15.3 3.3 50 0.58	 Additional information: x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process	NSSC
Chemical consumption, %	6.2 SO ₂
Kappa number	95.6
Yield (unscreened), %	64.7
Screenings, %	
Brightness	37.7
Beater or refiner	PFI
Freeness	300 CSF
Tensile index, N m/g	47.5
Burst index, kPa m ² /g	
Tear index, mN m ² /g	7.5

Bleached

Sequence	CECEH
Chemical consumption, %	17.5 Cl ₂
Yield on bleaching, %	77.3
Total yield, %	50.0
Brightness	80.6
Beater or refiner	PFI
Freeness	250 CSF
Tensile index, N m/g	93
Burst index, kPa m ² /g	
Tear index, mN m ² /g	9.1

Additional information: Data are given on the results of a variety of pulping and bleaching conditions.

The results above are obtained of the pulps cooked to the lowest kappa no. in the study.

Scientific name: <i>Eucalyptus globulus</i>	Common name: Country: Mexico	Reference: 69
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Campo Experimental "Siberia" in Chapingo, Estado de Mexico 12 years old	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 2.06 2.7 5.08 (hot) 13.05 0.54 21.1 15.4
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	Additional information: cellulose % 46.5 (Tappi)	
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Bisulphite (Mg)

7.4 SO₂ 6.2 - 11.0 SO₂ 9.9 - 17.0 SO₂
109.7 114.5 - 66.3 87.0 - 43.6
59.8 68.7 - 51.3 56.6 - 47.5

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI

300 CSF 300 CSF 300 CSF
39 37 - 49 48 - 56
1.6 1.5 - 3.0 2.0 - 3.3
4.3 4.0 - 5.7 4.7 - 5.4

Bleached

Sequence

Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

Eucalyptus grandis
(Rose Gum)

Plantation experience

This species is indigenous to New South Wales and Queensland in Australia. It is essentially a species of subtropical climates with good rainfall (1 - 1.8 metres), high humidity and no extremes of temperature other than light frosts in valleys. Development is best on friable or moist alluvial loams of good fertility with ample soil moisture. Under favourable conditions it grows rapidly, 2 m in height and 12 - 20 mm in diameter per year. Under typical Australian conditions individual trees attain a height of 45 - 55 metres with a diameter at breast height 1.2 - 1.5 metres.

It is extensively planted in the Republic of South Africa, Swaziland and Zambia and is adaptable to the southern Florida climate. Plantations exist also in Argentina, Brazil and India. The growth rate is good (Zambia), a 5-year old tree attains a height of 20 - 23 m with 16 - 20 cm diameter at breast height. In Florida it can be harvested on an 8-year rotation basis.

References: 8, 21, 30, 35, 38, 43, 54, 66

Wood characteristics

The wood is lighter, softer and more fissile than in most eucalypt species, moderate in strength and durability. The fibre length is in the range normal for hardwoods used for pulping. The fibres are relatively thin. There is, however, considerable difference in wall thickness between samples of different origin. In general the fibres seem to have reasonable flexibility and thus provide potential for good inter-fibre bonding in paper. Judging from the chemical composition, no special problems are expected in pulping although the lignin content of the Brazilian samples is slightly on the high side for hardwoods.

Pulping experience

As noted in the previous volume, the best results in sulphate pulping are obtained with fairly low alkali charges. The pulp yields are then within the range normal for hardwoods. The strength of the unbleached pulp is very good, although an influence of sample origin is observable. The bleached pulps are also of good strength. NSSC pulping seems to produce pulps of very good quality in normal yields. The results on chemi-thermomechanical pulping (CTMP) have been characterized as reasonable though inferior to those of *E. regnans*.

<p>Scientific name: Eucalyptus grandis</p>	<p>Common name: Rose Gum Country: Brazil</p>	<p>References: 8</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p>a) 5 - 16 years old b) 5 - 7 years old</p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ 407 - 597 Fibre length, µm x) 840 - 1 280 Fibre width, µm 17.0 - 20.5 Wall thickness, µm 3.2 - 5.1 Lumen width, µm 7.8 - 12.2 Length/width ratio Runkel ratio Flexibility ratio</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, % Ether Methanol Ethanol-benzene 1.8 - 2.6</p> <p>Solubility, % in water in 1 % NaOH 1.2 - 3.2 (hot)</p> <p>Ash, % Lignin, % Holocellulose, % Cross-Beyan cellulose, % Pentosans, % 26.2 - 27.0 55.0 - 56.4 17.3</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information: x

Permanganate Number

Sulphate

14.0 - 15.0

49.6 - 54.5

40 - 45 SR

66 - 116

5.0 - 6.5

12.1 - 15.3

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Brazil	References: 9
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in the region of Linhares 4 years old (average)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	3.2 3.3 (hot) 15.8 0.3 26 54.2 19.4
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process	Sulphate	Sulphate
Chemical consumption, %	14.0 Na ₂ O (charge)	12.0 Na ₂ O (charge)
Kappa number x	11.8	18.0
Yield (unscreened), %	50.2	51.3
Screenings, %	0.1	1.2
Brightness xx	41.5	31.7
Beater or refiner	Jokro	
Freeness	30 SR	30 SR
Tensile index, N m/g	102	105
Burst index, kPa m ² /g	6.5	7.9
Tear index, mN m ² /g	11.0	10.0
		45 SR
		109
		8.3
		9.7
		60 SR
		110
		8.5
		9.5

Bleached

Sequence	CEHDED	CEHDED
Chemical consumption, %		
Yield on bleaching, %	94.6	91.0
Total yield, %	47.4	45.6
Brightness xx	86.0	88.0
Beater or refiner	Jokro	
Freeness	30 SR	30 SR
Tensile index, N m/g	82	105
Burst index, kPa m ² /g	4.9	7.2
Tear index, mN m ² /g	10.4	11.4
		45 SR
		118
		7.5
		11.2
		60 SR
		120
		8.0
		11.3

Additional information: x Permanganate Number (ABCP C4/71)

xx ABCP P16/73

<p>Scientific name: <i>Eucalyptus grandis</i></p>	<p>Common name: Rose Gum</p> <p>Country: Brazil</p>	<p>References:</p> <p>10</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p>Sample from Mogi Guacu - Sao Paulo</p> <p>7 years old</p>	<p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ 581</p> <p>Fibre length, µm x) 1 060</p> <p>Fibre width, µm 18.6</p> <p>Wall thickness, µm 3.2</p> <p>Lumen width, µm 12.2</p> <p>Length/width ratio 57</p> <p>Runkel ratio 0.525</p> <p>Flexibility ratio 0.66</p>	<p>Additional information:</p> <p>x) 1000 µm = 1mm</p>
<p><u>Chemical characteristics:</u></p> <p>Extractives, %</p> <p>Ether 2.6</p> <p>Methanol</p> <p>Ethanol-benzene</p> <p>Solubility, %</p> <p>in water 3.2 (hot)</p> <p>in 1 % NaOH 13.7</p> <p>Ash, % 26.2</p> <p>Lignin, % 55.0</p> <p>Holocellulose, % 17.3</p> <p>Cross-Bevan cellulose, %</p> <p>Pentosans, %</p>	<p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number x
Yield (unscreened), %
Screenings, %

Sulphate
13.0 Na₂O (charge)
14.4
49.6
1.5

Brightness

Beater or refiner
Freeness
Tensile index, M m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
25 SR
88
5.1
14.2

45 SR
98
6.2
13.8

77 SR
112
8.3
13.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, M m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information: x Permanganate Number

<p>Scientific name: <i>Eucalyptus grandis</i></p>	<p>Common name: Rose Gum Country: Australia</p>	<p>Reference: 36</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ 444 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, % Ether Methanol Ethanol-benzene</p> <p>Solubility, % in water in 1 % NaOH</p> <p>Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process CTMP

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness (Elrepho)

Beater or refiner

Freeness

Tensile index, M m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bauer

334 CSF

24

4.3

276 CSF

30

4.3

84.0

32.4

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, M m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

x Solution containing 1.6 % NaOH and 1.25 % Na₂SO₃

Liquor: wood ratio 5 : 1

<p>Scientific name: Eucalyptus grandis</p>	<p>Common name: Rose Gum Country: USA</p>	<p>References: 38</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u> Sample from the plantation in La Belle, Florida</p> <p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 430 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p> <p><u>Additional information:</u> x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p> <p><u>Additional information:</u></p>	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate x
20.2 (charge)
9.5

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

500 CSF

400 CSF

3.5
8.4

4.1
8.6

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD

(GE)

87.9

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

500 CSF

400 CSF

2.4
6.4

3.0
6.3

Additional information:

x Mill trials, unbarked

<p>Scientific name: <i>Eucalyptus grandis</i></p>	<p>Common name: Rose Gum Country: Argentina</p>	<p>References: 43</p>
Wood sample characteristics		
<p><u>Wood sample origin:</u> Sample from "la Estación Experimental Castelar del Ministerio de Agricultura"</p> <p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 352 - 417 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p> <p>Additional information: x) 1000 µm = 1 mm</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water 1.9 - 2.1 3.8 - 4.3 (hot) in 1 % NaOH 16.8 - 19.0 Ash, % Lignin, % 21.7 - 26.8 Holocellulose, % Gross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

	Sulphate	Sulphate
	18.0 - 19.5 NaOH	16.2 - 18.7 NaOH (charge)
	17.5 - 20.5	22
	46.2 - 49.9	46.8 - 51.8
	0.9 - 1.2	1.5 - 3.5

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

	Valley
	40 SR
	102 - 128
	6.4 - 8.1
	8.2 - 8.4

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

	CEH	CEHEH	CEHEH
	68.8 - 71.1	83.1	86.4 - 87.2

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

	Valley	40 SR	40 SR
		119 - 133	112 - 134
		7.4 - 7.9	7.2 - 8.6
		8.1 - 8.3	7.6 - 9.7

Additional information:

Scientific name: Eucalyptus grandis	Common name: Rose Gum Country: Zambia	References: 54
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Chatli forest 5.5 years old average breast height girth 74 cm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bavan cellulose, % Pentosans, %	1.0 2.1 (hot) 13.8 0.2 23.2 69.5
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	 	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, % x

Sulphate
9.5 Na₂O
88.5
61.0
5.4

12.0 Na₂O
32.2
54.1
3.6

13.0 Na₂O
20.5
49.4
0.3

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
250 CSF
102
7.0
11.3

335 CSF
95
6.2
11.1

PFI
245 CSF
125
9.0
11.1

365 CSF
118
7.9
10.8

PFI
280 CSF
130
8.4
9.9

420 CSF
110
7.2
11.2

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
7.4 C12
47.0

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
285 CSF
103
7.4
10.2

465 CSF
77
5.0
9.7

Additional information:

x on o.d. screened pulp

Eucalyptus macarthuri

Plantation experience

No information available.

Wood characteristics

The basic density and the chemical composition do not differ from those of hardwoods normally used for pulping.

Pulping characteristics

Sulphate pulping gives pulp in somewhat lower yield than usual for hardwoods. However, the strength characteristics are representative of good quality eucalypt pulp.

<p>Scientific name: Eucalyptus</p>	<p>Common name: Country: Argentina</p>	<p>Reference: 43</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origins</u> Sample from "la Estación Experimental castelar del Ministerio de Agricultura"</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p>	<p>0.2 - 2.0 13.5 - 17.3 1.3 - 3.6 (hot) 19.4 - 23.0</p>
<p><u>Density and fibre characteristics:</u> Basic density, kg/m³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p>	<p>442 - 444</p>	<p>Additional information: x) 1000 µm = 1mm</p>

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
17.0 NaOH
20 - 23
47.8 - 50.7
1.1 - 2.3

Sulphate
16.4 - 17.2 NaOH (charge)
22
47.7 - 51.3
2.0 - 3.5

Brightness

Beater or refiner

Valley
40 SR

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

104 - 127
6.8 - 8.3
8.2 - 9.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEH

CEHEH

CEHEH

Brightness

69.1 - 71.9

83.4 - 84.1

86.7 - 87.4

Beater or refiner

Valley

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

40 SR

103 - 126
6.7 - 8.2
7.7 - 11.0

Additional information:

Eucalyptus maculata

Plantation experience

No information available.

Wood characteristics

The basic density is higher than normal for hardwoods used for pulping and the fibre length is below average. The fibres are thin but thick-walled which indicates a certain stiffness and consequently, a low bonding potential in paper. The lignin content is somewhat below average for hardwoods.

Pulping characteristics

The yield figures obtained in sulphate pulping are slightly below average for hardwoods. Although the tensile and burst indices are below average for eucalypt sulphate pulp, the tear index is instead relatively high.

Scientific name: <i>Eucalyptus maculata</i>	Common name: Country: Brazil	Reference: 29
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in "Estado de Minas Gerais" 7 years old	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water 2.1 in 1 % NaOH 4.6 (hot) 19.9 Ash, % 0.48 Lignin, % 17.5 Holocellulose, % Cross-Beman cellulose, % 58.8 Pentosans, % 24.7	
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 885 Fibre length, µm x) 17.2 Fibre width, µm 4.5 Wall thickness, µm 8.1 Lumen width, µm 52 Length/width ratio 1.1 Runkel ratio 0.47 Flexibility ratio	Additional information: x) 1000 µm = 1mm	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate
13.5 Na₂O

48.7
3.7

Jokro
30 SR
70
4.4
12.2

45 SR
86
6.0
13.9

60 SR
95
7.0
12.5

Scientific name: <i>Eucalyptus maculata</i>	Common name: Country: Australia	Reference: 71
Wood sample characteristics		
<u>Wood sample origin:</u> 35 years old, half cross section <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 662 Fibre length, μ m x) Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkal ratio Flexibility ratio Additional information: x) 1000 μ m = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate

14.0 - 17.0 Na₂O (charge)

12.0 - 14.7

49.0 - 53.3

PFI

350 CSF

70 (approx.)

10.5 (approx.)

Eucalyptus maidenii

Plantation experience

The species is one of the most adaptable eucalyptus species. It has not, however, been much used in plantations on a commercial scale. Very good results have been obtained in Italy, Portugal and Zaire and satisfactory in Kenya, Malawi, Rhodesia and the Republic of South Africa. In general, the best results have been obtained at appropriate altitudes in countries with a tropical climate. For additional information and a list of references see the previous volume (21).

Wood characteristics

The basic density of the wood is in the normal range of hardwoods used for pulping. No data on the fibre characteristics have been published lately. The chemical characteristics do not indicate any difficulties in chemical pulping.

Pulping characteristics

With normal alkali charges in the sulphate pulp is obtained in low to average yields. The pulps are readily bleached and the strength properties of both the unbleached and bleached pulps are of average level or slightly below for eucalypt sulphate pulps.

<p>Scientific name: Eucalyptus maidenii</p>	<p>Common name: Country: Argentina</p>	<p>References: 43</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u> Sample from "la Estación Experimental Castelar del Ministerio de Agricultura"</p> <p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 539 - 576 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p> <p>Additional information: x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water 1.1 - 3.7 2.7 - 6.3 (hot) in 1 % NaOH 13.5 - 20.7 Ash, % 21.8 - 23.2 Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freemess

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freemess

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate
14.3 - 21.5 NaOH (charge)
22

45.7 - 54.5

0.8 - 4.0

Sulphate
16.5 - 20 NaOH
18 - 22.5

46.5 - 52.6

1.0

Valley

40 SR

94 - 98

5.9 - 6.0

7.6 - 10.2

CEH

CEHEH

CEHEH

66.6 - 68.5

81.9 - 82.1

85.6 - 86.9

Valley

40 SR

100 - 103

6.0 - 6.2

7.4 - 10.5

40 SR

98 - 99

6.3 - 6.5

8.5 - 10.6

Eucalyptus marginata

Plantation experience

This species is one of the three main species in the hardwood forest zone in Western Australia. It is the principal timber tree of the state, large, attaining a height of 30 - 40 m and a diameter of 1.8 m. It occurs in relatively pure stands with a small admixture of E. calophylla and E. patens on all but the poorest sandy soils. No results on plantation experience of the species have been reported.

References: 55

Wood characteristics

The basic density of the wood is within the range normal for hardwoods used for pulping. The fibre length is about the average for hardwoods. No other data on the fiber dimensions or chemical composition of the species are available.

Pulping characteristics

The yield of the pulp in the sulphate process is low. The Kappa number obtained is, however, relatively high and pulping to a Kappa number of 20 would cause additional decrease in the yield. The strength properties are comparable to the average quality of eucalypt pulps.

Application of the NSSC process gives pulp acceptable for corrugating medium but not for paper.

Poor strength and reddish brown colour of cold soda and groundwood pulps would rule against the use of either of these processes.

Scientific name: Eucalyptus marginata	Common name: Country: Australia	Reference: 55
Wood sample characteristics		
<u>Wood sample origin:</u> Samples from Pemberton and the Pimelia district 26 - 30 year old thinnings <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 581 Fibre length, μ m x) 1 150 Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 μ m = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
14.0 Na₂O (charge)
34.0
45.2

NSSC
x
68.9

NSSC
xx
67.7

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Lampen
305 CFS
95
6.3
10.6

Lampen
418 CFS
45
2.0
5.4

341 CFS
49
2.2
4.9

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information: x 14 % Na₂SO₃ + 6 % NaHCO₃ (charge)
xx 18 % " " " "

Eucalyptus nitens

Plantation experience

No information available.

Wood characteristics

The basic density and chemical composition data are in the range normal for hardwoods used for pulping, whereas the fibre length is somewhat below average.

Pulping characteristics

The sulphate process gives pulp in slightly below average yield which is easily bleached to high brightness. The strength characteristics of the unbleached and bleached pulp correspond to average quality eucalypt sulphate pulp.

Scientific name: <i>Eucalyptus nitens</i>	Common name: Country: New Zealand	References: 34
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Tokoroa district 6 years old 20 trees, mean height 13.4 m, mean diam. 171 mm (breast height)	<u>Chemical characteristics:</u> Extractives, % Ether 1.1 Methanol Ethanol-benzene Solubility, % in water 2.2 (hot) in 1 % NaOH 17.2 Ash, % 22.5 Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: x) 1000 μ m = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
14.0 - 16.0 Na₂O (charge)
37.2 - 21.4
52.4 - 49.7

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

D_CEHD

Brightness 90.4 - 91.6

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Lampen
350 CSF
84
6.2
9.9
322 CSF
92
6.8
9.7

Additional information:

Eucalyptus ovata

Plantation experience

Good results have been obtained in Algeria and the Republic of South Africa. The species is possibly useful in the wetter Mediterranean climatic zones where the winter is too cold for other species. It has proved to be very resistant to frost and summer drought. For further information see the previous volume (21).

Wood characteristics

The basic density of the wood is within the range normal for hardwoods used for pulping. No data on the fibre characteristics are available. The chemical characteristics do not indicate difficulties in chemical pulping.

Pulping characteristics

Sulphate pulping gives good to normal yields with relatively small alkali charges when pulped to a Kappa number of 20. The strength properties of both the unbleached and bleached pulps are about the average for eucalypt pulps.

Scientific name: <i>Eucalyptus ovata</i>	Common name: Country: Argentina	Reference: 43
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from "la Estación Experimental Castelar del Ministerio de Agricultura".	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 0.3 14.2 1.9 (hot) 22.7
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	584	Additional information: x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
16.5 NaOH
16.5
52.6
0.9

Sulphate
14.3 NaOH (charge)
22
54.2
6.7

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Valley
40 SR
95
5.5
10

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEH

CEHEH

CEHED

Brightness (Tappi)

70.2

82.9

87.9

Beater or refiner

Valley

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

40 SR
93
5.9
10

40 SR
102
6.2
9.2

Additional information:

Eucalyptus paniculata

Plantation experience

No information available

Wood characteristics

The basic density of the wood is higher than that of hardwood normally used for pulping and the fibre length somewhat shorter than average, although there probably is an increase in these characteristics with age. The fibre dimensions imply an undesirable stiffness which reduces the bonding potential in paper. The lignin content in the older sample is high for a hardwood.

Pulping characteristics

The sulphate process gives pulp in comparatively low yield, especially in view of the amount of screenings obtained. The strength characteristics correspond in general to those of a beech sulphate pulp, except for the tear index which is very good.

Scientific name: Eucalyptus paniculata	Common name: Country: Brazil	Reference: 29
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in "Estado de Minas Gerais" 6 and 10 years old	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 0.95 - 1.32 Solubility, % in water in 1 % NaOH 4.3 - 5.5 (hot) 15.4 - 16.1 Ash, % Lignin, % Holocellulose, % Cross-Beyan cellulose, % Pentosans, % 0.38 - 0.64 17.8 - 26.5 58.4 - 63.0 19.6 - 25.0	Additional information: x) 1000 μm = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio 680 - 721 871 - 938 16.7 - 16.9 6.0 - 6.2 4.6 - 4.7 52 - 55 2.6 - 2.7 0.27 - 0.28	Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Sulphate

13.0 Na₂O (charge)

47.1 - 51.7

2.1 - 2.9

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Jokro

30 SR

66 - 72

3.8 - 4.1

12.3 - 12.8

45 SR

77 - 80

5.1 - 5.3

12.1 - 14.4

60 SR

82 - 85

5.7 - 6.0

11.4 - 13.8

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Eucalyptus regnans

Plantation experience

The species is adaptable to various parts of the world including countries of inter-tropical zones. The growth is very rapid in early life. Fairly good results have been obtained in New Zealand, the Republic of South Africa and Argentina. For further information and references see the previous volume (25).

References: 21, 43

Wood characteristics

The density of the wood is lower than in most eucalypt species, but still in the normal range of hardwoods used for pulping. The fibres are of average length for hardwoods. No data on other fibre dimensions are available at hand. The chemical characteristics do not reveal anything that could cause difficulty in chemical pulping.

Pulping characteristics

The species is readily pulped in the sulphate process. The yields obtained with normal alkali charges are high as commonly found in eucalypts used for pulping. The strength properties of the unbleached pulps are good and they are readily bleached to high brightness levels without substantial loss in the strength properties. Cooking with saturated SO_2 -vapor gives pulps of high brightness and strength comparable to commercial hardwood acid sulphite pulps.

Refiner pulps of poor quality are obtained. Thermomechanical pulping (TMP) yields considerably better but still unsatisfactory results. Chemi-thermomechanical pulping (CTMP) gives pulps of reasonable quality. At yields of 85 - 90 % a satisfactory range of properties are obtained indicating that CTMP could be considered as a component of newsprint, printing and writing papers and possibly other grades (39). The results on chemi-mechanical (cold soda) pulping have been characterized as reasonable.

Scientific name: <i>Eucalyptus regnans</i>	Common name: Country: New Zealand	References: 34
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Tokoroa district 14 years old 10 trees, mean height 28.2 m, mean diam. 287 (breast height)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.0 Solubility, % in water in 1 % NaOH 1.2 (hot) 12.8 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 21.3	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 393 Fibre length, µm x) 1 000 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate

16.0 - 20.0 Na₂O (charge)

13.6 - 23.9

53.4 - 53.8

D_C EHD

91.2 - 92.7

Lampen

350 CSF

122

8.7

9.1

420 CSF

112

7.8

9.7

<p>Scientific name: <i>Eucalyptus regnans</i></p>	<p>Common name: Country: Australia</p>	<p>References: 36</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u> 12 years old</p> <p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 426 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p> <p><u>Additional information:</u> x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene</p> <p>Solubility, % in water in 1 % NaOH</p> <p>Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p> <p><u>Additional information:</u></p>	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Gold Soda

4 NaOH 8 NaOH

92.8

52.2

Bauer

109 - 309 CSF 294 CSF

13 - 22 42

0.26 - 0.71 1.7

2.3 - 2.8 4.8

27.4

PFI

543 CSF

16

0.39

1.9

36.2

358 CSF

14

0.17

1.6

176 - 250 CSF

30 - 64

5.2 - 5.5

P

71.2 - 71.7

x Solution containing 1.6% NaOH and 1.25% Na₂SO₃

Liquor: wood ratio 5:1

Scientific name: <i>Eucalyptus regnans</i>	Common name: Country: Australia	References: 42
Wood sample characteristics		
<u>Wood sample origin:</u> Mt Hooglily, Victoria 27 years old, a single tree sample	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, μ m x) Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio	Additional information: x) 1000 μ m = 1mm	

Pulping and papermaking characteristics

Unblended

Process

Chemical consumption, % x

Kappa number

Yield (unscreened), %

Screenings, %

Brightness (Elrepho)

Beater or refiner

Freedom

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, m^2/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

References

Tensile index, $K = g$ Burst index, $\text{kPa} \cdot \text{m}^2/\text{g}$

Tear index, m

Additional information:

a) Chips impregnated with NH_4HSO_3 51.8% on o.d. wood
x S consumption at 55% yield 32 kg S/tonne o.d. pulp produced

a) Chips impregnated with NH_4HSO_3 51.8% on o.d. wood

b)	"	"	Na_2SO_3	26.1%	"	"
b)	"	"	Na_2SO_3	26.1%	"	"

Scientific name: Eucalyptus regnans	Common name: Country: Argentina	References: 43
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from "la Estacion Experimental Castelar del Ministerio de Agricultura"	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 0.9 14.3 1.9 (hot)
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 490 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	<u>Additional information:</u>	
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

	Sulphate	Sulphate
	17.0 NaOH	15.5 NaOH (charge)
	16.5	22
	54.1	55.8
	1.0	5.8

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

	Valley
	40 SR
	136
	9.0
	9.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

	CEH	CEHEH	CEHEED
--	-----	-------	--------

Brightness (Tappi)

	78.0	87.1	89.9
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Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

	Valley	40 SR	40 SR
		130	122
		8.4	8.7
		8.6	9.4

Additional information:

Eucalyptus robusta
(Swamp Mahogany)

Plantation experience

The species is very widespread throughout the world. Good results have been obtained in Brasil, Chile, India, Madagascar, Malawi, Malaysia, Mauritius and Zaire. It has been planted also in Cyprus, Florida, Italy, North Africa, Portugal and Spain. In general, the species grows well on deep, moist soils and shows fairly good adaptability to subtropical land and to intertropical high altitude zones. For additional information and a list of references see the previous volume (21).

References: 22

Wood characteristics

The basic density is in the range normal for hardwoods used for pulping. The fibres are of average length for hardwoods, wide and thin-walled, which implies a certain amount of flexibility and thus potential for good inter-fibre bonding in paper.

Pulping characteristics

The species has been pulped in the sulphate process with relatively low alkali charges to the normal Kappa number levels for hardwoods. The yields obtained are slightly below the average for hardwoods. The strength properties of the pulps range from average to good for eucalypt pulps.

NSSC pulping gives high yields with acceptable strength properties of the pulps obtained.

Scientific name: <i>Eucalyptus robusta</i>	Common name: Country: Brazil	Reference: 10
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Mogi das Cruzes - Sao Paulo 6.5 years old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 452 Fibre length, µm x) 1 070 Fibre width, µm 19.0 Wall thickness, µm 3.4 Lumen width, µm 12.1 Length/width ratio 56 Runkel ratio 0.561 Flexibility ratio 0.64 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number x
Yield (unscreened), %
Screenings, %

Sulphate

11.5 - 14.5 Na₂O (charge)
26.7 - 14.8
50.2 - 48.2
8.1 - 2.7

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro

15 SR
10 - 40
1.0 - 1.5
6.5 - 7.0
30 SR
73 - 120
6.1 - 7.0
12.0 - 13.5
50 SR
90 - 136
7.6 - 8.0
11.7 - 12.2

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information: x Permanganate Number

Scientific name: <i>Eucalyptus robusta</i>	Common name:	References: 30
	Country: U.S.A.	
Wood sample characteristics		
<u>Wood sample origin:</u> Florida 10 years old (approximately)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 449 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio		Additional information: x) 1000 μm = 1mm

Eucalyptus saligna

Plantation experience

Remarkable results have been achieved in more or less tropical areas, in Brasil and in the Republic of South Africa. Very encouraging results have been obtained in Argentina, Chile, Rhodesia, Nigeria, Malawi, Sri Lanka and Kenya. Plantations exist also in Congo, Zaire, Spain and Italy. The species is not very resistant to frost and several failures have been recorded with trials of this species in low-lying equatorial zones. For detailed information and a list of references see the previous volume (21).

Wood characteristics:

The density of the wood is in the range normal for hardwoods used for pulping and the wood can easily be debarked. There is considerable influence of provenance on the dimensions of the fibres. In general, the fibres are of average length, maybe slightly on the wide side and fairly thin-walled with flexibility ratios up to 0.68. This implies potentially good inter-fibre bonding in paper. The lignin content also varies considerably depending on the origin of the sample (from low to high compared with the average of hardwoods). The amount of extractives is high in some samples and may cause difficulties in pulping.

Pulping characteristics

The variations in fibre and chemical characteristics reflect also on the pulping results. The yield in sulphate pulping is about 50 percent and the strength properties vary from below average to good for eucalypt pulps.

The results obtained on Mg-bisulphite pulping indicate that the species can be considered a good raw material for the process in proper conditions. The quality of the cold soda pulps are good in respect of the high yields and low alkali charges used. The yields of thermomechanical pulps are high and quality comparable to the cold soda pulps obtained with very low alkali charges. The application of peroxide bleaching increases the brightness substantially, but no results are given on other properties of the bleached pulps.

Scientific name: <i>Eucalyptus saligna</i>	Common name: Country: Brazil	Reference: 2
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m^3 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) $1000 \mu\text{m} = 1\text{mm}$	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process	Cold soda	Cold soda	TMP	TMP
Chemical consumption, %	2.7 Na ₂ O	0.9 Na ₂ O	0.7 Na ₂ O	-
Kappa number				
Yield (unscreened), %	90	93	94	96
Screenings, %				
Brightness	43	47	49.5	47.5
Beater or refiner				
Freeness	60 CSF	60 CSF	60 CSF	60 CSF
Tensile index, N m/g	41	23	25	20
Burst index, kPa m ² /g				
Tear index, mN m ² /g	4.0	2.3	3.1	2.1

Bleached

Sequence	P	P	P	P
Chemical consumption, %	1.5 H ₂ O ₂	1.5 H ₂ O ₂	1.5 H ₂ O ₂	1.5 H ₂ O ₂
Yield on bleaching, %				
Total yield, %				
Brightness	62	69	63	62
Beater or refiner				
Freeness				
Tensile index, N m/g				
Burst index, kPa m ² /g				
Tear index, mN m ² /g				

Additional information:

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Bisulphite (Mg)

4.0 - 6.0 SO₂ (charge)

32.8 - 103.0

47.3 - 67.4

0.1 - 10.1

Jokro

30 SR

42 - 73

2.1 - 4.0

6.0 - 9.1

45 SR

41 - 75

2.1 - 4.3

5.4 - 9.0

60 SR

38 - 69

1.8 - 3.9

4.8 - 8.1

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Bisulphite (Mg)

31.0 - 101.1

48.6 - 57.9

Sulphate

41.2 - 55.3

45 SR

41 - 75

2.1 - 4.3

5.4 - 9.0

36 - 45 SR

58 - 122

5.3 - 8.2

8.6 - 13.3

Scientific name: <i>Eucalyptus saligna</i>	Common name: Country: Brazil	References: 10
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Mogi Guaçu - São Paulo 5 years old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 495 Fibre length, µm x) 1 010 Fibre width, µm 19.1 Wall thickness, µm 3.1 Lumen width, µm 12.9 Length/width ratio 53 Runkel ratio 0.481 Flexibility ratio 0.68 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.4 Solubility, % in water 3.0 (hot) in 1 % NaOH 13.1 Ash, % 26.3 Lignin, % Holocellulose, % 54.1 Cross-Bevan cellulose, % Pentosans, % 17.8 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate

13.0 Na₂O (charge)

20.5

50.2

1.1

Jokro

25 SR

83

5.1

11.6

40 SR

97

6.6

12.5

70 SR

107

7.4

12.7

Scientific name: <i>Eucalyptus saligna</i>	Common name: Country: Brazil	References: 27
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the area of Mogi Guacu in the state of Sao Paulo 8 years old <u>Density and fibre characteristics:</u> Basic density, kg/m^3 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) $1000 \mu\text{m} = 1\text{mm}$	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate x
9.0 Na₂O (charge)
20 - 60
47.5 - 50.9
0.5 - 5.3

Sulphate
12.5 Na₂O (charge)
30
50.0
3.4

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
30 SR
68 - 78
4.0 - 4.5
10.7 - 13.4

40 SR
73 - 87
4.8 - 5.7
11.5 - 12.0

50 SR
83 - 93
5.5 - 6.4
12.0 - 12.1

30 SR
83
5.9
14.0

40 SR
94
7.4
12.2

50 SR
102
8.2
12.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information: x Rapid alkaline pulping (Kleinert)

Scientific name: Eucalyptus saligna	Common name: Country: Brazil	Reference: 29
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from "Champion Papel e Cellulose S.A., Mogi Guacu 8 and 13 years old	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 1.6 - 1.7 4.7 - 7.4 (hot) 17.8 - 20.8 0.2 - 0.3 18.7 - 21.6 57.4 - 61.5 16.9 - 18.8
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	 48 - 51 1.3 - 1.4 0.42 - 0.43 Additional information:	
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate

13.0 - 14.0 Na₂O (charge)
23
46.5 - 50.3
1.9 - 3.7

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro

30 SR
88
4.9
12.8

60 SR
103
7.3
12.5

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

Scientific name: <i>Eucalyptus saligna</i>	Common name: Country: Brasil	Reference: 32
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Escola Superior de Florestas in Viscoosa, Minas Gerais state	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 900 Fibre length, µm x) 19.8 Fibre width, µm 4.3 Wall thickness, µm 11.1 Lumen width, µm Length/width ratio Runkel ratio 0.78 Flexibility ratio 0.56		Additional information: x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
25 Na₂O (charge)
18.5
43.1
0.03

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

350 CSF
134
6.8
11.1

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

<p>Scientific name: <i>Eucalyptus saligna</i></p>	<p>Common name: Country: Argentina</p>	<p>References: 43</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u> Sample from "la Estacion Experimental Castelar del Ministerio de Agricultura"</p> <p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 369 - 474 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p> <p>Additional information: x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether 0.5 - 1.3 Methanol 15.0 - 15.2 Ethanol-benzene 2.2 - 2.8 (hot) Solubility, % in water 0.5 - 1.3 in 1 % NaOH 15.0 - 15.2 Ash, % 25.9 - 29.5 Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
17.5 - 18.0 NaOH
20.0 - 21.0
50.5 - 51.0
0.7 - 0.9

Sulphate
16.5 - 17.5 NaOH (charge)
22
50.7 - 52.0
1.2 - 1.9

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Valley
40 SR
102 - 134
6.3 - 8.8
8.3 - 9.1

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEH
CEHEH
CEHEH

Brightness (Tappi)

70.6
82.9
86.5

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Valley
40 SR
112
8.9
7.9
40 SR
113
8.5
9.5

Additional information:

Eucalyptus sieberi

Plantation experience

This is one of the main species available in New South Wales, Australia. Regeneration after fire in some areas has given rise to extensive stands of small trees. No reports on cultivation of the species are available.

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping. No other wood data are available for the present sample.

Pulping characteristics

The pulp yield in the sulphate process is fairly good in view of the low Kappa number of the pulps obtained. The strength properties of the pulps do not seem to be below average although there is some variation in the results. In general, it seems that it is not necessary to remove the smooth inner bark of the logs to obtain satisfactory pulp. The bleachability of the pulp from unbarked logs is not significantly inferior to pulp made from debarked wood.

<p>Scientific name: <i>Eucalyptus sieberi</i></p>	<p>Common name:</p> <p>Country: Australia</p>	<p>References: 71</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p>a) 25 years old</p> <p>b) composite sample of different ages</p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m^3 a) 555</p> <p>Fibre length, μm x)</p> <p>Fibre width, μm</p> <p>Wall thickness, μm</p> <p>Lumen width, μm</p> <p>Length/width ratio</p> <p>Runkel ratio</p> <p>Flexibility ratio</p> <p>Additional information:</p> <p>x) $1000 \mu\text{m} = 1\text{mm}$</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, %</p> <p>Ether</p> <p>Methanol</p> <p>Ethanol-benzene</p> <p>Solubility, %</p> <p>in water</p> <p>in 1 % NaOH</p> <p>Ash, %</p> <p>Lignin, %</p> <p>Holocellulose, %</p> <p>Cross-Bevan cellulose, %</p> <p>Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

<u>Unbleached</u>	a)	b) Unbarked	Debarked
Process	Sulphate	Sulphate	Sulphate
Chemical consumption, %	14 - 17 Na ₂ O	14.0 Na ₂ O	14.0 Na ₂ O
Kappa number	10.1 - 13.4	20.7	15.7
Yield (unscreened), %	50.1 - 51.4	48.9	50.6
Screenings, %			
Brightness			
Beater or refiner	PFI	PFI	PFI
Freeness	350 CSF	122 CSF	335 CSF
Tensile index, N m/g	105 (approx.)	87	69
Burst index, kPa m ² /g		5.4	3.7
Tear index, mN m ² /g	13 (approx.)	11.3	9.4
			125 CSF
			93
			5.6
			10.8
<u>Bleached</u>			
Sequence		CEHD	CEHD
Chemical consumption, %			
Yield on bleaching, %		42.3	46.2
Total yield, %			
Brightness (Elrepho)	84.3	83.4	84.7
Beater or refiner	PFI	PFI	PFI
Freeness	338 CSF	242 CSF	360 CSF
Tensile index, N m/g	57	70	64
Burst index, kPa m ² /g	3.4	4.3	3.9
Tear index, mN m ² /g	9.1	9.0	9.4
Additional information:	x	charge	

Eucalyptus tereticornis

Plantation experience

Good results of this species have been obtained on a small scale in Indonesia and Zaire. It has successfully been raised in India and shown to be adaptable in Florida. The results in Brazil have been less successful. As an exotic it has been introduced in Italy, Spain, Portugal, Cyprus and North Africa. It has exhibited inferior growth in semi-arid zones and low resistance to drought. It cannot be acclimatized at low altitudes.

References: 21, 22, 29, 30

Wood characteristics

The wood of the present samples is of medium density for hardwoods although densities of 850 - 1 050 kg/m³ have been reported in samples from natural stands in Australia and a density of about 650 kg/m³ is considered normal for the species in India. The fibres are of average length, fairly thin and of normal wall thickness for hardwoods, which implies a good opacity in pulps made from the species. The chemical characteristics do not reveal anything that would cause difficulties in chemical pulping. On the other hand, the wood has proved to be difficult to debark.

Pulping characteristics

Sulphate pulping requires relatively low alkali charges and gives low pulp yields compared to average hardwoods. The strength properties, especially the tear index, are good for both unbleached and bleached pulps. The opacity and brightness of the pulps are good. On the other hand, the costs of bleaching are somewhat higher than average. The yield of dissolving pulp is low, both the brightness and the α -cellulose level are comparable to those of average hardwoods. NSSC pulping gives high yields and pulps of acceptable quality. Please note that these findings refer only to the present samples of a density lower than normal for the species in general. Higher density species have in general exhibited lower strength values.

Scientific name: <i>Eucalyptus tereticornis</i>	Common name: Country: Brazil	References: 29
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in "Estado de Minas Gerais" 7 years old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 512 Fibre length, µm x) 828 Fibre width, µm 14.8 Wall thickness, µm 4.2 Lumen width, µm 6.3 Length/width ratio 56 Runkel ratio 1.33 Flexibility ratio 0.43 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether 0.56 Methanol Ethanol-benzene Solubility, % in water 5.1 (hot) in 1 % NaOH 17.2 Ash, % 0.30 Lignin, % 22.8 Holocellulose, % 60.2 Cross-Bevan cellulose, % 19.3 Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, % x Sulphate 13.0 Na₂O

Kappa number

46.2

Yield (unscreened), %

2.1

Screenings, %

Brightness

Beater or refiner

Jokro

Freeness

30 SR

Tensile index, N m/g

77

Burst index, kPa m²/g

5.1

Tear index, mN m²/g

14.0

60 SR

98

7.3

13.4

45 SR

88

6.4

13.2

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

x charge to Permanganate number 16.0 ± 1.0

Scientific name: <i>Eucalyptus tereticornis</i>	Common name: Country: U.S.A.	Reference: 30
Wood sample characteristics		
<u>Wood sample origin:</u> Florida 10 years old (approximately)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 a) 577 b) 497 c) 497 - 545 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 μm = 1mm

Pulping and papermaking characteristics

	a)	b)	c)
<u>Unbleached</u>			
Process	NSSC	Sulphate	Sulphate
Chemical consumption, %			
Kappa number	38	9 x	12 - 20
Yield (unscreened), %	75 (screened)	32 (screened)	36 - 43
Screenings, %			

Brightness

Beater or refiner	
Freeness	400 CSF
Tensile index, N m/g	65
Burst index, kPa m ² /g	3.6
Tear index, mN m ² /g	

Bleached

Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	

Brightness

Beater or refiner	
Freeness	92
Tensile index, N m/g	92 - 93
Burst index, kPa m ² /g	300 CSF
Tear index, mN m ² /g	7.4 - 7.6
	13.0

Additional information:

x Tappi 40 ml

b) Dissolving pulp commercial

c) commercial bleached grade kraft pulp

Eucalyptus tessellaris

Plantation experience

No information available.

Wood characteristics

The basic density is in the range normal for hardwoods used for pulping and the fibre length somewhat below average. However, the latter may be due to the sample being from a tree only four years old. There would probably be an improvement in the other fibre dimensions with age as well, but taking the values as such, there would seem to be an undesirable stiffness in the fibres. The lignin content is somewhat high for a hardwood.

Pulping characteristics

The yield on sulphate pulping is below average for hardwoods. The quality of the pulp, both unbleached and bleached is below average for eucalypt pulp and resembles beech pulp. However, note that the sample is very young and the results should be seen in the light of this fact.

Scientific name: <i>Eucalyptus tessellaris</i>	Common name: Country: Brazil	References: 9
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in the region of Linhares 4 years old (average) <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 560 Fibre length, µm x) 850 Fibre width, µm 16.2 Wall thickness, µm 5.0 Lumen width, µm 6.1 Length/width ratio 52 Runkel ratio 1.64 Flexibility ratio 0.38 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.1 Solubility, % in water 5.2 (hot) in 1 % NaOH 17.2 Ash, % 0.6 Lignin, % 24.1 Holocellulose, % Cross-Bevan cellulose, % 49.6 Pentosans, % 20.6 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %
Brightness x
Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Sulphate
14.0 Na₂O (charge)
17
46.1
0.1
40.2
Jokro
30 SR
78
4.8
8.6
45 SR
88
5.6
9.0
60 SR
93
6.0
8.4
30 SR
73
4.6
11.3
45 SR
85
5.8
10.2
60 SR
92
6.4
9.6
Sulphate
13.0 Na₂O (charge)
23
47.5
0.5
33.3

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %
Brightness x

CEHDED
94.0
43.2
86.6
CEHDED
89.3
42.0
89.3

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
30 SR
61
3.2
8.0
45 SR
66
3.6
7.6
60 SR
69
3.8
7.4
30 SR
60
3.3
9.4
45 SR
64
3.9
9.8
60 SR
66
4.1
9.0

Additional information: x ABCP P16/73

Eucalyptus torelliana

Plantation experience

The species is native to N. Queensland, Australia and is exceptional in growing within the margin of tropical rainforests. Trial plantations have been established in Argentina, Brasil, Nigeria, Nyasaland, Sudan, Congo, Cyprus, India, Malaysia, Australia, Solomon Islands and Hawaii.

References: 22

Wood characteristics

The basic density of the wood is in the range normal for hardwoods used for pulping. It should be noted that the sample is taken for very young trees and consequently it can be expected that the fibre dimensions would be different in more mature trees. However, the sample as such contains comparatively short fibres with a certain amount of stiffness which would affect the potential bonding in paper. The chemical composition does not imply any difficulty on chemical pulping.

Pulping characteristics

The yield of pulp in the sulphate process is slightly under average for hardwoods. The strength characteristics of the pulp correspond to average quality eucalypt sulphate pulp.

Scientific name: Eucalyptus torelliana	Common name: Country: Brasil	Reference: 9
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantations in the region of Linhares 4 years old (average)	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bévan cellulose, % Pentosans, %	 2.0 2.9 (hot) 18.5 1.0 22.0 52.9 23.0
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	 465 810 17.2 4.7 7.8 47 1.21 0.45	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Brightness x

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Sulphate
14.0 Na₂O
17
51.5
0.1
33.8

Sulphate
13.0 Na₂O
23
50.5
0.4
28.8

Jokro
30 SR
85
5.4
8.7

45 SR
101
6.5
8.2

60 SR
109
7.1
8.0

30 SR
80
5.1
8.6

45 SR
83
6.0
8.8

60 SR
94
6.4
9.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness x

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

CEHDED
95.0
48.8
87.5

CEHDED
91.5
45.8
90.0

Jokro
30 SR
75
4.0
8.5

45 SR
82
4.7
9.0

60 SR
86
5.0
8.6

30 SR
75
5.4
8.4

45 SR
79
5.5
8.1

60 SR
81
5.6
8.0

Additional information:

x ABCP P16/73

Eucalyptus viminalis

Plantation experience

Remarkable growth rates have been obtained in the Mediterranean area, especially in Portugal. Encouraging results have also been obtained in California, Brazil, Chile, the Republic of South Africa and at high altitudes in India, Tanzania and Zaire. The species is fairly frost-hardy and mostly utilized in the cooler temperature subhumid sector of the summer rainfall zone. For additional information and references see the previous volume (21).

References: 10, 21

Wood characteristics

The basic density is in the normal range of hardwoods used for pulping. The fibre length is about the average for hardwoods. The fibres are of intermediate length, comparatively thin and thin-walled. A certain amount of flexibility and thus good inter-fibre bonding in paper is to be expected. Chemical data do not imply any difficulties in chemical pulping.

Pulping characteristics

Sulphate pulps with yields somewhat lower than average are obtained with relatively low alkali charges. The strength properties are about the average for eucalypt sulphate pulps. It has also been reported that after removal of leaves and twigs during the harvesting operation, the remainder material above ground is suitable for pulp and paper or fibre-board production.

Scientific name: <i>Eucalyptus viminalis</i>	Common name: Country: Brasil	References: 10
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Tres Barras - so. 11 years old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 512 Fibre length, µm x) 1 130 Fibre width, µm 16.8 Wall thickness, µm 3.4 Lumen width, µm 10.1 Length/width ratio 67 Runkel ratio 0.673 Flexibility ratio 0.60 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.6 Solubility, % in water 3.8 (hot) in 1 % NaOH 12.2 Ash, % Lignin, % 23.2 Holocellulose, % Cross-Bevan cellulose, % 52.4 Pentosans, % 17.3 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number x
Yield (unscreened), %
Screenings, %

Sulphate
12 - 16 Na₂O (charge)
16.1 - 10.6
50.4 - 46.5
1.0 - 0.2

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
15
32 - 36
1.2 - 1.5
5.8 - 6.8
30 - 33 SR
77 - 87
5.0 - 6.8
10.2 - 11.4
44 - 48 SR
84 - 97
4.3 - 7.6
10.9 - 12.4
70 - 78 SR
83 - 109
5.1 - 7.8
10.2 - 11.2

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information: x Permanganate Number

Gmelina arborea
(Yemane)

Plantation experience

The species is widely cultivated in areas such as South America, Africa and South-East Asia. The tree grows on various soils but seems to thrive best in valleys on moist fertile alluvium with good drainage. The samples referred to here are from Belize, Nigeria, Papua New Guinea and the Philippines. For example, the growth in Belize was 35 m³/ha·a at a rotation of 8 years.

References: 21, 48

Wood characteristics

The wood density exhibits great variation from below average to average for hardwood for pulping. The lignin content of the samples vary from high to very high, and the fibres are short or very short. The fibres are comparatively broad, and in certain cases the fibre wall is extremely thick.

Pulping characteristics

The wood is easily pulped by the sulphate process to low Kappa numbers, to high or very high yields. The tear index of the pulp is of medium class, except for those trees that provide very thick walled fibres. The bleaching response is quite good, but the pulp strength may be sensitive to the bleaching process. The wood species is more suitable for TMP and CTMP than for FMP, but the pulp brightness is relatively low. It should be noted that it is used for chemical pulping in Brazil and plans exist for its use for pulping in Nigeria.

Scientific name: <i>Gmelina arborea</i>	Common name: Africa - no further Country: information available	Reference: 6
Wood sample characteristics		
<u>Wood sample origin:</u> 38 logs, average diameter 140 mm Approximate age 10 a <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 430 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 0.7 - 0.9 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

CTMP

TMP

RMP

43.0

51.5

52.3

156

124

103

32

20

13

1.5

0.7

0.4

4.8

3.1

1.6

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

peroxide

hydrosulfite

hydrosulfite

1.7

1

2

58.4

59.6

61.9

264

147

119

27

16

13

1.0

-

0.4

3.7

2.2

1.9

Additional information:

Scientific name: <i>Gmelina arborea</i> Roxb.	Common name: Yemane Country: Philippines	References: 20
Wood sample characteristics		
<u>Wood sample origin:</u> Samples from forest plantation of the Paper Industry Corporation of the Philippines in Surigao, Mindanao	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 980 Fibre length, µm x) 30 Fibre width, µm 5 Wall thickness, µm 20 Lumen width, µm 33 Length/width ratio 0.50 Runkel ratio 0.67 Flexibility ratio	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

(Cook 223)

Sulphate (170°C, sulfidity 15%)
83.1 based on chem. charged
11.4
55.7
0.1

(Cook 4)

Sulphate (170°C, sulfidity 25.5%)
95.6
10.4
55.8
0.1

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Valley

400

97

5.85

6.2

Valley

400

120

7.0

5.5

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Scientific name: Gmelina arborea Roxb.	Common name: Country: Belize	References: 48
Wood sample characteristics		
<u>Wood sample origin:</u> From plantation at Silkgrass Age 8 a Five trees sampled: diameter 258 mm Growth 35 m ³ /ha.a <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 391 Fibre length, µm x) 850 Fibre width, µm 26 Wall thickness, µm 2.8 Lumen width, µm 20 Length/width ratio 33 Runkel ratio 0.28 Flexibility ratio 0.77 Additional information:	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.9 Solubility, % in water in 1 % NaOH 13.6 Ash, % 0.7 Lignin, % 24.7 Holocellulose, % 67.9 Cross-Bevan cellulose, % Pentosans, % Additional information:	
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°C)
13.7 act. alkali as Na₂O
24.7
50.2
0.0

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
500
82
5.6
10.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
8.9 as Cl
47.4

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

86
PFI
515
66.8
4.1
8.1

Additional information:

Scientific name: <i>Gmelina arborea</i>	Common name: Country: Papua New Guinea	References: 56
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the plantation at Brown River Forest Station, Port Moresby 5 years old, one dominant tree (butt, middle and top logs) <u>Density and fibre characteristics:</u> Basic density, kg/m^3 346 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 μm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
13.0 Na₂O (charge)
18.6
52.8
0.7

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

PFI

300 CSF

105 (approx.)

11 (approx.)

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Scientific name: <i>Gmelina arborea</i> Roxb.	Common name: Country: Nigeria	References: 62 - 65
Wood sample characteristics		
<u>Wood sample origin:</u> Samples collected at Ifara Plantation Farm Age 8 a, diameter 240 mm	<u>Chemical characteristics:</u> Extractives, % Ether 2.8 Methanol 4.2 Ethanol-benzene (1:2) 4.0 Solubility, % in water 3.1 (cold) 5.2 (hot) in 1 % NaOH 15.3 Ash, % 0.9 Lignin, % 29.7 Holocellulose, % 79.6 Cross-Bevan cellulose, % Pentosans, % 14.0	 <

Pulping and papermaking characteristics			
<u>Unbleached</u>	(165°C/120°C, 0.8 MPa)	(150°C, 0.5 MPa)	(170°C)
Process	Soda-oxygen (pulp II)	H ₂ S-kraft (pulp II)	NSSC (pulp II)
Chemical consumption, %			chlorine number 30.2
Kappa number	38.4	24.7	78.6
Yield (unscreened), %	52.8	52.7	
Screenings, %			
Brightness	35.4	23.6	37.9
Beater or refiner	PFT	PFT	PFT
Freeness SR	30	30	30
Tensile index, N m/g	75.8	94.0	107.6
Burst index, kPa m ² /g	4.93	6.65	7.97
Tear index, mN m ² /g	7.56	8.64	8.88
<u>Bleached</u>			
Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m ² /g			
Tear index, mN m ² /g			
Additional information:			

Scientific name: <i>Gmelina arborea</i> Roxb.	Common name: Country: Nigeria	References: 62 - 65
Wood sample characteristics		
<u>Wood sample origin:</u> Same as previous sample	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 μm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness (SCAN)

Beater or refiner

(Freeness) SR

Tensile index, $M \frac{m}{g}$

Burst index, $kPa \frac{m^2}{g}$

Tear index, $mN \frac{m^2}{g}$

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

(Freeness) SR

Tensile index, $M \frac{m}{g}$

Burst index, $kPa \frac{m^2}{g}$

Tear index, $mN \frac{m^2}{g}$

Additional information:

Sulphate (165°C) Sulphate (165°C) Sulphate-oxygen (MPa/110°C)

20.1 21.1 20.9) after cooking
52.5 52.5 52.5)
3.9 1.9

31.4

PFI

29

86.4

6.36

9.46

CEDED

8.4 as act. Cl

95.6

CEDED

4.1 as active Cl

97.9

92.5

PFI

22

68.9

4.64

8.48

91.2

PFI

22

74.7

5.05

10.1

Scientific name: <i>Gmelina arborea</i> Roxb.	Common name: Yemane Country: Philippines	References: 70
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 1 300 Fibre length, µm x) 31 Fibre width, µm 3.5 Wall thickness, µm 24 Lumen width, µm 42 Length/width ratio 0.29 Runkel ratio 0.77 Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: Straight bole. Resistant to fire At 3 years: DBH 194 mm. Growth over 100 m ³ /ha.a x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
Kappa number x
Yield (unscreened), %
Screenings, %

Sulphate (170°C, 25.5% sulkidity, 15.6% act. alk.)
95.6 based on chem. charged
11.4
55.8
1.1

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Valley
500
94.5
4.65
6.6

Bleached

Sequence

Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEH
3.7 as Cl-charge
96.0

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

77.0
Valley
500
65.0
5.4
5.4

Additional information: x Permanganate Number

Scientific name: <i>Guasuma crinita</i> Mart.	Common name: Bolaina Country: Peru	References: 37
Wood sample characteristics		
<u>Wood sample origin:</u> Sample size 20 kg Length growth 2 - 3 m (Diameter 150 mm) <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 338 Fibre length, µm x) 1 410 Fibre width, µm 26 Wall thickness, µm 4.6 Lumen width, µm Length/width ratio 54 Runkel ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % 1.0 Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % 0.2 Lignin, % 21.6 Holocellulose, % Cross-Bevan cellulose, % 49.9 cellul. Pentosans, % Additional information: Hemicellulose, % 27.3	

x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (165°C)
15 charge of act. alkali as Na₂O
21.0
49.2
5.3

Brightness

29

Beater or refiner

Valley

Freeness

30 SR

Tensile index, N m/g

94.0

Burst index, kPa m²/g

6.9

Tear index, mN m²/g

9.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information: Fibre weight 74 µg/m

Paulownia fortunei

Plantation experience

The usable height of the tree is 6.5 m at 2 years rotation. The wood sample studied is taken from an experimental plantation in Italy.

References: 13

Wood characteristics

The wood density of this very young sample is very low and the fibres are probably due to the age of the sample, shorter than average for hardwoods. The lignin content is in the range normal for hardwoods, but the extractives content is high.

Pulping characteristics

This particular wood sample was converted into high-yield NSSC and sodium bisulphate pulps as well as refiner mechanical pulp (RMP). The results indicate that there is promise for practical use of this species as raw material for chemimechanical pulps for various purposes.

Scientific name: <i>Paulownia fortunei</i>	Common name: Country: Italy	References: 13
Wood sample characteristics		
<u>Wood sample origin:</u> From a trail plantation near Rome Mean annual temperature 15°C Mean annual precipitation 780 mm Age 2 a Usable height 6.5 m <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 227 Fibre length, µm x) 840 Fibre width, µm 33 Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio 25 Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % 0.98 Ether Methanol Ethanol-benzene 6.4 Solubility, % in water in 1 % NaOH Ash, % 0.2 Lignin, % 21.0 Holocellulose, % 73.2 Cross-Beyan cellulose, % Pentosans, % Additional information: Hemicellulose, % 27.1	

x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, $N\ m/g$

Burst index, $kPa\ m^2/g$

Tear index, $mN\ m^2/g$

KSSC (165°C)

18

75

60 OE

40 SR

85

4.5

5.7

Na-bisulphite

73

60 OE

40 SR

80

4.4

4.9

RMP

115 CSF

22

0.8

3.5

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, $N\ m/g$

Burst index, $kPa\ m^2/g$

Tear index, $mN\ m^2/g$

Additional information:

Pinus caribaea
(Caribbean Pine)

Plantation experience

This species is native to British Honduras, Central America, Cuba and the south-eastern parts of the United States. The wood is naturally durable and it may, if desired, be successfully treated with wood preservatives. The species consists of three different varieties (P. caribaea var bahamensis, var caribaea and var hondurensis), which are slightly different with respect to soil and climate requirements. The present samples are from Bahamas, Cuba, Belize, Brazil, Tanzania, Sabah and Fiji and they represent almost only plantation trees 6 - 24 years old. In Tanzania the annual growth was 20 m³/ha at about 6 years rotation. See also the previous volume (21).

References: 21, 46, 67

Wood characteristics

The wood density of trees older than about 20 years is in the medium range or high range. The fibres are of short to average length for softwood, but their width is comparatively large. The wall thickness may be considered as common for softwoods. The lignin content of the wood is around average or slightly higher than for softwoods in general.

Pulping characteristics

The sulphate pulps yield is low (40 - 45%) at Kappa numbers regarded as typical or low for chemical sulphate pulps (25 - 30). The pulp strength indicated by the tear index corresponds to that of Scandinavian pine whereas the corresponding tensile strength resembles that of U.S. southern pine pulp. A four-stage bleaching sequence seems to give acceptable brightness with normal charges of chlorine, but there is some risk of losses in tear strength loss.

Scientific name: <i>Pinus caribaea</i> var <i>hondurensis</i>	Common name: Country: Sabah	References: 15
Wood sample characteristics		
<u>Wood sample origin:</u> Six trees (9.5 a). Seed from British Honduras DEH 169 mm under bark	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 0.9 Solubility, % in water in 1 % NaOH 2.9 hot Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 30.2 61.7	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio 445	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Prehydrolysis-kraft
20 (170°C)

Sulphate
20 (170°C)

Chemical consumption, % x)
Kappa number
Yield (unscreened), %
Screenings, %

22.2
34.7
0.1

Brightness

Beater or refiner

Freeness

Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEDED
8.0 (chlorine)

CEDED
9.4 (available Cl)

Brightness

Beater or refiner
Freeness

Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

38.1
61.2 (Elrepho)
88.0
16.9

32.7
82.6
96.2
10.1

Additional information: x) Active alkali charge as Na₂O xx) Time to 170°C 1 h, at 0.5 h

Scientific name: <i>Pinus caribaea</i>	Common name: Country: Brazil	References: 26
Wood sample characteristics		
<u>Wood sample origin:</u> Plantation 8 years <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 353 Fibre length, µm x) 3 610 Fibre width, µm 54 Wall thickness, µm 5.1 Lumen width, µm 44 Length/width ratio 67 Runkel ratio 0.23 Flexibility ratio 0.81 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.7 Solubility, % in water 1.3 in 1 % NaOH 11.0 Ash, % 0.3 Lignin, % 30.8 Holocellulose, % Cross-Bevan cellulose, % 46.3 Pentosans, % 8.9 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°C)
20
25
44.5
1.6

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
x)
63.27
4.42
15.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

x) at sheet density 600 kg/m³

Scientific name: <i>Pinus caribaea</i>	Common name: Country: Tanzania	References: 46
Wood sample characteristics		
<u>Wood sample origin:</u> Trial plantation 70 km from Dar-Es-Salaam, 80 m above sea level. DBH 143 mm, mean annual increment 20 m ³ /ha.a. Age 6.5 a. 15 logs from five trees <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 380 Fibre length, μ m x) 2 800 Fibre width, μ m 51 Wall thickness, μ m 4.9 Lumen width, μ m Length/width ratio 55 Runkel ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.4 Solubility, % in water in 1 % NaOH 10.5 Ash, % Lignin, % 28.7 Holocellulose, % 60.7 Cross-Bevan cellulose, % Pentosans, %	Additional information: x) 1000 μ m = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, % x)

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information: x) Na₂O active alkali

Sulphate

14.2

28.1

42.3

0.3

Sulphate semiochemical

10 (charge)

61

PFI

500

76.0

5.3

14.0

PFI

410

69.4

5.3

13.4

CEHD

10.1 (chlorine)

95.3

40.1

78.7 (Elrepho)

PFI

500

78.0

5.2

12.5

<p>Scientific name: <i>Pinus caribaea</i> var <i>bahamensis</i></p>	<p>Common name:</p> <p>Country: Bahamas</p>	<p>References: 47</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p>Sample from a natural forest on Great Abaco Island. 30 - 50 years old.</p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ 520 Fibre length, µm x) 2 700 Fibre width, µm 41 Wall thickness, µm 7.5 Lumen width, µm</p> <p>Length/width ratio Runkel ratio Flexibility ratio</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, % Ether Methanol Ethanol-benzene 3.9</p> <p>Solubility, % in water in 1 % NaOH 12.5</p> <p>Ash, % Lignin, % 27.4 Holocellulose, % 64.2 Cross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p> <p>a cellulose % 48.4</p>	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
14.0 Na₂O
32.5
40.5
0.8
13.3 Na₂O
42.6
42.9
3.2

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
300 CSF
71
4.5
15.5
PFI
300 CSF
69
4.4
13.0

Bleached x

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
9.9 Cl
95.0
38.4

Brightness (Elrepho)

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
210 CSF
70
4.3
11.8
PFI
440 CSF
62
3.9
13.2

Additional information: x unbleached pulp; kappa 25.4, yield 40.4%

Scientific name: Pinus caribaea var caribaea	Common name: Country: Cuba	References: 50
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from 12 year old plantation at Topes de Collantes, Las Villas , 10 trees sampled <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 433 Fibre length, µm x) 2 370 Fibre width, µm 52 Wall thickness, µm 5.0 Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether 1.7 Methanol Ethanol-benzene Solubility, % in water 12.0 in 1 % NaOH Ash, % Lignin, % 28.9 Holocellulose, % 58.3 Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°C)
14.8 act. alkali as Na₂O
26.2
42.3
0.0

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
500
63
4.3
10.2

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
9.8 as Cl
96.0
40.6

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

83
PFI
500
58
3.8
9.6

Additional information:

Scientific name: Pinus caribaea	Common name:	References: 51
	Country: Belize	
Wood sample characteristics		
<u>Wood sample origin:</u> From plantations in the Coastal Plain. Five trees sampled at five heights in the stem. Samples from Melinda plantation 11, 17 and 24 year old trees <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 478 557 593 Fibre length, µm x) 2 060 2 330 3 060 Fibre width, µm 45 49 46 Wall thickness, µm 4.8 5.4 5.9 Lumen width, µm Length/width ratio 46 48 67 Runkel ratio Flexibility ratio <u>Additional information:</u> Diameter, mm 204 318 230 Height, m 12.5 16.0 15.7 x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.2 2.1 4.3 Solubility, % in water in 1 % NaOH 10.5 11.4 13.3 Ash, % Lignin, % 28.1 27.3 26.3 Holocellulose, % 60.7 61.7 60.9 Cross-Bevan cellulose, % Pentosans, % <u>Additional information:</u>	

Pulping and papermaking characteristics

<u>Unbleached</u>	11	17	24 a	11	17	24 a
Process		Sulphate			Sulphate	
Chemical consumption, % x)	13.6	13.4	13.2	14.5	14.1	14.2
Kappa number	39.5	37.9	39.3	28.8	28.0	30.1
Yield (unscreened), %	46.6	45.3	44.9	43.1	43.8	42.4
Screenings, %	1.0	1.1	1.9	0.3	0.2	0.4
<u>Brightness</u>						
Beater or refiner	PFI	PFI	PFI	PFI	PFI	PFI
Freeness	500	500	500	500	500	500
Tensile index, N m/g	74	74	69	69	69	66
Burst index, kPa m ² /g	5.2	5.6	4.9	4.7	4.9	4.6
Tear index, mN m ² /g	17.5	17.7	20.7	15.9	16.5	19.0

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

x) Active alkali as Na₂O

Scientific name: Pinus caribaea Mor. var hondurensis	Common name: Country: Fiji	Reference: 53
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Drasa plantation, 9 years dd. Diameter (10% height) 184 and 124 mm under bark for fast and slow grown trees respectively <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 421 442 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.3 1.1 Solubility, % in water 2.0 2.3 in 1 % NaOH 11.2 11.0 Ash, % Lignin, % 28.6 28.6 Holocellulose, % 60.2 60.2 Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

<u>Unbleached</u>		Fast	Slow grown
Process		Sulphate	Sulphate
Chemical consumption, % x)		15.0	14.1
Kappa number		26.5	28.0
Yield (unscreened), %		42.3	43.3
Screenings, %		0.1	0.1
Brightness			
Beater or refiner		PFI	PFI
Freeness		445	470
Tensile index, N m/g		65.3	74.5
Burst index, kPa m ² /g		4.3	5.0
Tear index, mN m ² /g		10.8	12.8
<u>Bleached</u>			
Sequence			
Chemical consumption, %			
Yield on bleaching, %			
Total yield, %			
Brightness			
Beater or refiner			
Freeness			
Tensile index, N m/g			
Burst index, kPa m ² /g			
Tear index, mN m ² /g			
Additional information:		x) Active alkali as Na ₂ O	

Pinus elliottii

(Slash Pine)

Plantation experience

Indigenous to the coastal plains of the south-eastern United States, this is one of the "southern pines". It is used in its natural habitat for afforestation of denuded land. It yields also high quality commercial turpentine containing a high proportion of beta pinene. It has been introduced in many countries, such as Brazil, Malawi and New Zealand from where the present samples have been taken. The results have been less satisfactory in Kenya and Malaysia. The growth rate obtained in New Zealand was almost $30 \text{ m}^3/\text{ha}\cdot\text{a}$ at 25 years rotation.

References: 21, 49, 68

Wood characteristics

The wood density varies very much from low to medium obviously due to differences in provenance and growing conditions. The fibres are mostly long and comparatively broad, but the fibre walls are of normal thickness. The lignin content is around average for softwoods.

Pulping characteristics

The sulphate pulp yield is on the average somewhat low but higher than that obtained with Caribbean pine, compared at the same degree of delignification. Typical yields are 44 - 46 percent. The strength characteristics of the pulps are in the range typical of U.S. southern pine pulps. The sample from New Zealand exhibits an extremely good tear index. The bleaching response is quite acceptable provided that proper bleaching sequences and suitable chlorine charges are used.

Scientific name: Pinus elliotii	Common name: Country: Malawi	Reference: 4
Wood sample characteristics		
<u>Wood sample origin:</u> 16 years old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 398 - 415 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio <u>Additional information:</u> x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % <u>Additional information:</u>	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, % x
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
18.5 Na₂O
28.6 - 30.4
46.0 - 46.4
0.5 - 0.8

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
30 SR
75 - 83
6.7 - 7.2
19.5 - 15.0

Bleached xx

Sequence
Chemical consumption, % x
Yield on bleaching, %
Total yield, %

D/CEHDED
10.5 Cl, 3.5 NaOH
94.2
46.4

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

89.7
Valley
30 SR
91
7.7
15.0

Additional information:

x charge
xx mixed sample, kappa of unbleached pulp 35.4

Scientific name: Pinus elliotii Engelman var. elliotii	Common name: Slash pine Country: U.S.A.	Reference: 26
Wood sample characteristics		
<u>Wood sample origin:</u> Plantation 18 years statistical treatment samples from 25 woods/species, 5 repetitions	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 <

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate (170°C)

20

25

44.0 ± 0.5

0.2 ± 0.1

Jokro

x)

99.06 ± 6.70

7.87 ± 0.35

15.3 ± 0.5

x) at sheet density 0.600 g/cm³

Scientific name: <i>Pinus elliotii</i> var. <i>elliottii</i>	Common name: Slash pine Country: Brasil	References: 26
Wood sample characteristics		
<u>Wood sample origin:</u> 8 years plantation	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.9 ± 0.6 Solubility, % in water in 1 % NaOH 1.5 ± 0.7 7.1 ± 1.4 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 0.3 ± 0.2 29.8 ± 1.1 49.1 ± 1.8 9.2 ± 1.1	Additional information: x) 1000 µm = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio 307 ± 8 3 140 ± 35 45.31 ± 2.68 5.41 ± 0.53 34.88 ± 2.97 69 ± 8 0.37 ± 0.074 0.77 ± 0.04	Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

Sulphate (170°C) bleachable

20
26.5 ± 2
44.6 ± 3.3
0.3 ± 0.2

Jokro
x)

59.58 ± 1.62
4.47 ± 0.23
12.7 ± 0.6

x) at sheet density 0.600 g/cm³

Scientific name: Pinus elliotii	Common name: Slash pine Country: Brasil	Reference: 39
Wood sample characteristics		
<u>Wood sample origin:</u> Plantation 10 year old	<u>Chemical characteristics:</u> Extractives, % 6.5 Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: Analysis of pitch
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) 3 200 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio		Additional information: x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°) industrial scale
20.19 (Na₂O)
74

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Hydradisc (600 HP)
x) 19° SR
81
3.5
12.5
Jordan (250 HP)
xx)
3.7
13.5

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

x) 80 g/cm³ xx) 160 g/cm³ (board)

Scientific name: <i>Pinus elliotii</i>	Common name:	Reference: 49
	Country: Malawi	
Wood sample characteristics		
<p><u>Wood sample origin:</u></p> <p>From 1 000 ha plantation in Vipya Temperature 14-20 °C, annual rainfall 115-1 650 mm Elevation 1 500 m above sea level Medium growth trees (5) 15 years old</p> <p>Diameter 195 mm</p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ 355 Fibre length, µm x) 2 030 Fibre width, µm 54 Wall thickness, µm 5.0 Lumen width, µm 44 Length/width ratio 38 Runkel ratio Flexibility ratio</p> <p>Additional information: Growth 14.0 m³/ha.a x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, % Ether Methanol Ethanol-benzene 1.5</p> <p>Solubility, % in water in 1 % NaOH 11.5</p> <p>Ash, % Lignin, % Holocellulose, % 58.4 Cross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, % x)

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

x) Act. alkali as Na₂O

Sulphate

13.8

27.6

46.1

0.0

500

73.0

5.0

11.0

CEH

7.0 added Cl

41.2

68

500

74.0

5.2

10.0

Scientific name: <i>Pinus elliotii</i>	Common name: Slash pine Country: New Zealand	Reference: 68
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Tairua Forest Wood age 25 a Growth rate 29 m ³ /ha.a	<u>Chemical characteristics:</u> Extractives, % 6.0 Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 370 (inner) 450 (outer wood) Fibre length, µm x) 3 000 - 4 500 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
 Kappa number
 Yield (unscreened), %
 Screenings, %

Sulphate (170°C)

30
 45.3

Brightness

Beater or refiner

Freeness

Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

PFI
 500
 70
 6.2
 21.7

Bleached

Sequence

Chemical consumption, %
 Yield on bleaching, %
 Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

Additional information:

Pinus halepensis

(Cyprus Pine)

Plantation experience

In its natural habitat the species is found mainly in Cyprus, Turkey, Syria and Iraq. It grows from sea level up to 1 500 m. The tree has been used extensively for afforestation. Plantations have shown promise in Australia and in south-east Africa. The present sample of 14 years old trees was taken in Italy.

Reference: 13, 21

Wood characteristics

The wood of medium density contains fibres which are somewhat shorter than average for a softwood. The lignin content is about average for softwoods.

Pulping characteristics

The sulphate cook performed at 175⁰C temperature and by application of reasonable quantities of chemicals gave pulps of normal degree of delignification, but in low yield. The strength properties are somewhat inferior to those of Scandinavian pine pulp. The brightness obtained after bleaching cannot be considered satisfactory in view of the five-stage sequence applied.

Scientific name: <i>Pinus halepensis</i>	Common name: Country: Italy	References: 13
Wood sample characteristics		
<u>Wood sample origin:</u> From a center near Rome Mean annual temperature 15°C Mean annual precipitation 780 mm Age 14 a Usable height 9 m <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 465 Fibre length, µm x) 2 420 Fibre width, µm 33 Wall thickness, µm 5.5 Lumen width, µm 22 Length/width ratio 73 Runkel ratio 0.50 Flexibility ratio 0.67 Additional information: x) 1000 µm = 1 mm	<u>Chemical characteristics:</u> Extractives, % 1.7 Ether Methanol Ethanol-benzene q 3.3 Solubility, % in water in 1 % NaOH Ash, % 0.4 Lignin, % 26.8 Holocellulose, % 70.1 Cross-Bevan cellulose, % Pentosans, % Additional information: Hemicellulose, % 29.0	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (175°C)
18 charge as act. alkali
35
43

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
32 SR
84
6.1
11.5

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHEH
10 charged as Cl

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

78 GE

Additional information:

Pinus insularis
(Benguet Pine)

Plantation experience

The present sample is from Luzon in the Philippines. The stem diameter at 30 years was 200 mm.

References: 11

Wood characteristics

Density and fibre dimensions are not available; the lignin content is around average for a softwood. The extracting content is comparatively low.

Pulping characteristics

The yield of sulphate pulp is high compared with values common for softwood sulphate pulps. The strength properties of the pulp are almost comparable to those of Scandinavian pine pulp.

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate (170°C)

13.6

27.4

49.6

0.7

470

11.9

8.0

13.4

Pinus kesiya

Plantation experience

The species is indigenous to Indochina. Acclimatization has been promising in South and East Africa, and partly also in Australia, but it has failed to acclimatize in Fiji, Malaysia, Borneo and Uganda. The present samples are from India and Malawi. The Indian sample represents one tree about 30 years old and with a diameter of 300 mm.

References: 12, 21

Wood characteristics

The wood density is low to average for softwoods and the fibre length is about average. The lignin content is within the range normal for softwoods.

Pulping characteristics

The yield of pulping is low to average for softwoods and the strength characteristics correspond to those of Scandinavian pine pulps. The bleaching response is good.

Scientific name: <i>Pinus kesiya</i>	Common name: Country: Malawi	Reference: 4
Wood sample characteristics		
<u>Wood sample origin:</u> <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 324 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm - 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, % x)
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate

20.0 Na₂O
30.7
46.0
0.4

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
30 SR
87
7.8
12.5

Bleached xx)

Sequence
Chemical consumption, % x)
Yield on bleaching, %
Total yield, %

D/CEHDED
9.3 Cl, 3.1 NaOH
95.0
46.8

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Valley
30 SR
101
8.3
11.5

Additional information:

x) Charge
xx) Mixed sample, kappa of unbleached pulp 30.0

Scientific name:	Pinus khasya	Common name:	Reference: 12
		Country:	India
Wood sample characteristics			
<u>Wood sample origin:</u> From experimental plot in Mayurbhanj. Annual rainfall 1 450 - 1 700 mm. Elevation 600-900 m above sea-level. One tree sampled: diameter 318 mm Tree age 30-35 a		<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 3.44 Solubility, % in water in 1 % NaOH 12.7 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 1.7 30.1 58.4 10.3	
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio 498 at 3 m height 3 560 52 6.1 68 0.76		Additional information:	
Additional information:			
x) 1000 µm = 1mm			

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
 Kappa number
 Yield (unscreened), %
 Screenings, %

Sulphate (170°C)
 13.6 act. alkali
 20.7
 41.3
 0.2

Brightness

Beater or refiner

Freeness
 Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %
 Yield on bleaching, %
 Total yield, %

CEHH
 7.5 total Cl
 92
 37.8

Brightness

Beater or refiner

Freeness
 Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

79 Elrepho
 Valley
 24 SR
 71.1
 3.5
 15.8

Additional information:

Pinus merkusii
(Mindoro Pine)

Plantation experience

This Malaysian species is the only pine species crossing the equator. This species grows at elevations over 500 m and the growth reported is 20 m³/ha·a at 25 years rotation. The present samples are both from Zambales in the Philippines.

References: 18, 45, 58

Wood characteristics

The wood density is somewhat above average for softwoods; the fibres are long and the lignin content about average. The fibres are broad and the fibre walls are extremely thick. The extractives content is in the range normal for softwoods.

Pulping characteristics

The sulphate pulp yield is low to average for softwoods. The tear factor of the pulp is very high, whereas the tensile strength is less satisfactory. However, the pulp corresponds in this respect to many U.S. southern pine pulps.

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Sulphate (170°C)

13.2 active alkali

21.2

45.9

0.7

400

93.5

7.0

18.8

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Scientific name: Pinus merkusii	Common name: Country: Philippines	Reference: 45
Wood sample characteristics		
<u>Wood sample origin:</u> Two trees from Zambales Mountains. Growth-rings (age) 80-100 <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 474-580 Fibre length, µm x) 2 970 Fibre width, µm 44 Wall thickness, µm 7.6 Lumen width, µm Length/width ratio 68 Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.9 Solubility, % in water in 1 % NaOH 10.9 Ash, % Lignin, % Holocellulose, % Cross-Beyan cellulose, % Pentosans, % 64.6 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate (165°C)

13.6 act. alkali

25.3

40.8

0.1

PFI

500

60.0

3.9

20.0

CEH

7.5 added Cl

39.4

65.4

PFI

550

59.9

4.2

15.6

Pinus occarpa
(Ocote Pine)

Plantation experience

The species grows at subtropical elevations in Mexico and in the mountains of Belize, Guatemala, Honduras, Nicaragua and Salvador. Successful acclimatization has been reported from Kenya and varying success from South Africa. The samples referred to are from a plantation in Brasil and from a natural stand in Belize.

References: 21, 52, 58

Wood characteristics

The wood density is around average for softwoods and the fibre length is in the high range. The fibres found in the young cultivated trees, 6 - 13 years old, are broad and extremely thick-walled. The content of lignin and extractives are typical for softwoods.

Pulping characteristics

The unscreened sulphate pulp yield is about average; the cultivated trees for some reason give pulps of very high screenings content. The tear index is very high, whereas the tensile strength on the other hand is fairly low, a common characteristic of U.S. southern pine pulps. A four stage bleaching sequence gives an acceptable brightness without detrimental effects on the pulp strength.

Scientific name: Pinus occarpa	Common name: Country: Brazil	Reference: 28																																
Wood sample characteristics																																		
<u>Wood sample origin:</u> Plantation in Agudos Tree age 6, 12 and 13 years <u>Density and fibre characteristics:</u> <table><tr><td>Basic density, kg/m³</td><td>362</td><td>412</td><td>441</td></tr><tr><td>Fibre length, µm x)</td><td>2 960</td><td>3 630</td><td>3 800</td></tr><tr><td>Fibre width, µm</td><td>43</td><td>48</td><td>49</td></tr><tr><td>Wall thickness, µm</td><td>5.7</td><td>7.8</td><td>9.0</td></tr><tr><td>Lumen width, µm</td><td>31</td><td>32</td><td>31</td></tr><tr><td>Length/width ratio</td><td>69</td><td>76</td><td>78</td></tr><tr><td>Runkel ratio</td><td>0.37</td><td>0.49</td><td>0.58</td></tr><tr><td>Flexibility ratio</td><td>0.72</td><td>0.67</td><td>0.63</td></tr></table>	Basic density, kg/m ³	362	412	441	Fibre length, µm x)	2 960	3 630	3 800	Fibre width, µm	43	48	49	Wall thickness, µm	5.7	7.8	9.0	Lumen width, µm	31	32	31	Length/width ratio	69	76	78	Runkel ratio	0.37	0.49	0.58	Flexibility ratio	0.72	0.67	0.63	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: Density measured on unextr. wood x) 1000 µm = 1mm
Basic density, kg/m ³	362	412	441																															
Fibre length, µm x)	2 960	3 630	3 800																															
Fibre width, µm	43	48	49																															
Wall thickness, µm	5.7	7.8	9.0																															
Lumen width, µm	31	32	31																															
Length/width ratio	69	76	78																															
Runkel ratio	0.37	0.49	0.58																															
Flexibility ratio	0.72	0.67	0.63																															

Pulping and papermaking characteristics

<u>Unbleached</u>	Age years:	6	12	13
Process		Sulphate (170°C)	do.	do.
Chemical consumption, %				
Kappa number		23.5	23.5	23.5
Yield (unscreened), %		44.6	47.7	49.7
Screenings, %		5.1	4.3	5.1
Brightness				
Beater or refiner				
Freeness	Sheet density	500	500	500
Tensile index, N m/g		4.9	5.2	5.9
Burst index, kPa m ² /g		3.4	4.3	4.3
Tear index, mN m ² /g		21.0	21.5	24.0
<u>Bleached</u>				
Sequence				
Chemical consumption, %				
Yield on bleaching, %				
Total yield, %				
Brightness				
Beater or refiner				
Freeness				
Tensile index, N m/g				
Burst index, kPa m ² /g				
Tear index, mN m ² /g				
Additional information:				

Scientific name: <i>Pinus oocarpa</i> var <i>ochoterenai</i>	Common name: Country: Belize	Reference: 52
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from stand of natural regeneration, Plot 8 in Mountain Pine Ridge, altitude 600 m Twenty trees selected. Average age 30 a, mean height of trees 20 m	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 3.8 Solubility, % in water in 1 % NaOH 15.1 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 28.7 67.5	Additional information: x) 1000 μ m = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 530 Fibre length, μ m x) 2 740 Fibre width, μ m 50 Wall thickness, μ m 6.9 Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio		

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (165°C)

12.9 active alkali as Na₂O
28.8
44.1
0.2

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

BFI
500
77
5.2
20.0

Bleached

Sequence

Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
10.8 as Cl
41.5

Brightness

Beater or refiner

Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

80 Elrephe
PFI
500
74
5.4
19.5

Additional information:

Pinus patula
(Patula Pine)

Plantation experience

The species is confined to elevations of 1 800 to 2 500 m on the moist mountains on the eastern side of the Mexican plateau between 19° and 21° north latitude. It is also found in Guatemala up to 3 000 m. It is well adapted to conditions in the mountains of eastern South Africa, where it has been planted since 1907. The species is introduced also in India, Australia and New Zealand. The present samples are from plantations in Kenya, Malawi and New Zealand, where the annual growth was as high as 30 m³/ha.

References: 21, 49, 58, 68

Wood characteristics

The wood density is in the range normal for softwoods used for pulping (350 kg/m³). The fibre length is about average, i.e. comparable with that of forest pine in northern Europe. Longer fibres have also been reported for older trees. The other fibre dimensions are quite similar to those of the "southern pines".

Pulping characteristics

By application of normal quantities of alkali in the sulphate cook, pulp is obtained in average yields (44 - 48 %). The tear index of chemical pulp is very high and on the whole, the strength characteristics resemble those of U.S. southern pine pulps. The three-stage bleaching has not been sufficient to produce brightness values over 70 units.

Scientific name: Pinus patula	Common name: Country: Kenya	References: 3
Wood sample characteristics		
<u>Wood sample origin:</u> Plantation-grown Under 7 a and 7-15 a logs <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 360 330 Fibre length, µm x) 2 070 3 010 Fibre width, µm 49 55 Wall thickness, µm 5.8 6.0 Lumen width, µm 37 43 Length/width ratio 42 55 Runkel ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.58 0.39 Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % 67.1 65.5 Cross-Bevan cellulose, % Pentosans, %	Additional information: x) 1000 µm = 1mm

Pulping and papermaking characteristics

<u>Unbleached</u>		
Process	< 7 a	7-15 a
Chemical consumption, % x)	Semi-kraft	Semi-kraft
Kappa number	12.7	13.3
Yield (unscreened), %	52.8	59.9
Screenings, %	2.0	4.3
Brightness		
Beater or refiner	Valley	Valley
Freeness	500	470
Tensile index, N m/g	93.1	97.3
Burst index, kPa m ² /g	6.8	6.9
Tear index, mN m ² /g	13.1	12.6

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information: x) Active alkali

Scientific name: Pinus patual	Common name: Country: Malawi	Reference: 4
Wood sample characteristics		
<u>Wood sample origin:</u> a) 12 years old b) 15 years old c) 16 years old <u>Density and fibre characteristics:</u> Basic density, kg/m^3 a) 353 b) 410 c) 349-387 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) $1000 \mu\text{m} = 1 \text{mm}$	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bever cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, % x)

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached xx)

Sequence

Chemical consumption, % x)

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

x) Charge

xx) Mixed sample (12-16 years old), kappa of unbleached pulp 38.6

a) Sulphate

17.0 Na₂O

42.2

48.1

1.3

b)

Sulphate

17.0 Na₂O

32.4 - 31.1

44.8 - 45.8

0.7 - 1.1

c)

Sulphate

18.5 Na₂O

31.0

47.6

1.2

PFI

30 SR

87

7.8

14.5

PFI

30 SR

79

7.2

16.5

PFI

30 SR

83

7.5

17.5

D/C EHDED

11.9 Cl, 3.7 NaOH

94.3

46.5

90.1

Valley

30 SR

97

8.0

15.0

D/C EHDED

13.8 Cl, 3.2 NaOH

93.4

45.9

89.2

Valley

30 SR

89

7.7

15.5

Scientific name: <i>Pinus patula</i>	Common name: Country: Malawi	References: 49
Wood sample characteristics		
<p><u>Wood sample origin:</u></p> <p>From 20 000 ha plantation in Vipya Temperature 14-20°C, annual rainfall 1 150 - 1 650 mm Elevation 1 500 m above sea-level Medium growth trees (5) 15 years old</p> <p>Diameter 199 mm</p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ 440 Fibre length, µm x) 2 040 Fibre width, µm 51 Wall thickness, µm 4.9 Lumen width, µm 41 Length/width ratio 40 Runkel ratio Flexibility ratio</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, % Ether Methanol Ethanol-benzene 2.3</p> <p>Solubility, % in water in 1 % NaOH 12.4</p> <p>Ash, % Lignin, % Holocellulose, % 60.4 Cross-Bevan cellulose, % Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process Sulphate
 Chemical consumption, % 13.2
 Kappa number 24.6
 Yield (unscreened), % 44.1
 Screenings, % 0.0

Brightness

Beater or refiner
 Freeness 500
 Tensile index, N m/g 78.0
 Burst index, kPa m²/g 5.5
 Tear index, mN m²/g 20.0

Bleached

Sequence CEH
 Chemical consumption, % 7 added chlorine
 Yield on bleaching, % 42.0
 Total yield, %

Brightness

Beater or refiner 63
 Freeness 500
 Tensile index, N m/g 80.0
 Burst index, kPa m²/g 5.6
 Tear index, mN m²/g 17.5

Additional information: Act. alkali as Na₂O

Scientific name:	Pinus patula	Common name:	References: 68
		Country:	New Zealand
Wood sample characteristics			
<u>Wood sample origin:</u> Sample from Rotoehu Forest Wood age 25 a Growth rate 30 m/ha.a		<u>Chemical characteristics:</u> Extractives, % 3.0 Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 360 (inner) 480 (outer wood) Fibre length, µm x) 2 600 4 900 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio		Additional information: x) 1000 µm = 1mm	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°C)

30
48.7

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
550
74
6.2
17.9

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

Pinus radiata
(Monterey Pine)

Plantation experience

This tree has been planted in Chile, Italy, Kenya, New Zealand, etc. A Mediterranean type climate, like in its natural habitat (southern California), seems to offer the most favourable growing conditions. The growth of the tree is in the medium range, and yields up to 40 m³/ha.a at a rotation of 25 years have been reported in New Zealand.

References: 21, 68

Wood characteristics

The density of wood in mature trees is about average for softwood. The average fibre length is between 2 and 4 mm depending upon tree age. Fibres of about 2 mm length were reported for trees 7 and 7 - 15 years old and cultivated in Kenya. No data on lignin contents are available.

Pulping characteristics

Mechanical pulp of suitable brightness and strength has been prepared from this wood. Chemimechanical sulphate pulps with average tear strength have been cooked to high yields, 60 - 65 percent. Chemical sulphate pulps obtained at average pulp yield show high tear values at low degrees of beating.

Scientific name: Pinus radiata	Common name: Country: Kenya	References: 3
Wood sample characteristics		
<u>Wood sample origin:</u> Plantation-grown Under 7 a and 7-15 a logs	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 0.80 2.06 63.6 61.4
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	 280 2 240 48 4.2 40 47	 360 2 150 42 4.6 33 51
Additional information: x) 1000 µm = 1mm	Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, % x)

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information: x) Act. alkali

7-15 a
semi-kraft
7.1

62.6
0.5

Valley
440

46.0

3.3

7.5

< 7 a
semi-kraft
7.1

67.8
3.7

Valley
490

50.4

3.6

8.0

Scientific name: <i>Pinus radiata</i>	Common name: Country: Australia	References: 16
Wood sample characteristics		
<u>Wood sample origin:</u> From Flynn Creek Tree Farm, Gippsland, Victoria age 10 a	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m^3 Fibre length, μm x) Fibre width, μm Wall thickness, μm Lumen width, μm Length/width ratio Runkel ratio Flexibility ratio	Additional information: x) 1000 μm = 1mm	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %
 Kappa number
 Yield (unscreened), %
 Screenings, %

Sulphate 177 °C

13 - 15 Na₂O
 35
 50
 2

22 sulphidity

Brightness

Beater or refiner

Lampen mill

Freeness
 Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

fertilized^x sterilized^x fertilized & sterilized^x
 600 600 600
 68.0 100.3 100.2
 7.2 7.6 7.7
 13.8 13.1 12.2

Bleached

Sequence

Chemical consumption, %
 Yield on bleaching, %
 Total yield, %

Brightness

Beater or refiner

Freeness
 Tensile index, N m/g
 Burst index, kPa m²/g
 Tear index, mN m²/g

Additional information:

x soil fertiliser treatment: P 250 kg/ha, K 630 kg/ha
 soil sterilisation: chloropicrin & bromide 336 kg/ha

Scientific name: Pinus radiata	Common name: Country: Chile	Reference: 17
Wood sample characteristics		
<u>Wood sample origin:</u> From mountains Nahuelbuta, Bio-Bio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	Additional information:	x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Mechanical pulp

60 (Elrepho)

105

28

5.2

Scientific name:	Pinus radiata	Common name:	References:
		Country: Italy	31, 60
Wood sample characteristics			
<u>Wood sample origin:</u> Sample from state forest "Sette Fratelli", Gagliari, Sardinia Wood age 33 a		<u>Chemical characteristics:</u> Extractives, % 3.10 Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ 510 Fibre length, µm x) 4 000 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio		Additional information:	
x) 1000 µm = 1mm			

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Scientific name: Pinus radiata	Common name: Monterey pine Country: New Zealand	References: 68
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Kaingaroa Forest Wood age 25 a Growth rate 40 m ³ /ha.a <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 370 (inner) 420 (outer wood) Fibre length, µm x) 2 100 - 3 900 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkal ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % 2.0 Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information: x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate (170°C)

30

47.8

PFI

625

89

7.4

14.3

Pinus taeda
(Loblolly Pine)

Plantation experience

This species is native to the eastern and southern U.S.A. It is the fastest growing species of the "southern pines". In its natural habitat it is planted on deforested land. Successful acclimatization has been reported from many countries in Africa, Asia and Australia. The results have been less good in Kenya. The present samples are from plantations in the U.S.A., Brazil and New Zealand. In New Zealand the growth was 30 m³/ha·a at 25 years rotation.

References: 21, 68

Wood characteristics

The wood density is in the range normal for softwoods used for pulping. The fibre length is slightly below average. The lignin content is in the range normal for softwoods.

Pulping characteristics

The sulphate pulp yield is low to average for softwoods. The strength characteristics are typical for a U.S. southern pine pulp.

Scientific name: Pinus taeda	Common name: Country: Brazil	Reference: 26
Wood sample characteristics		
<u>Wood sample origin:</u> Plantation 11 years <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 340 Fibre length, µm x) 2 780 Fibre width, µm 43.81 Wall thickness, µm 4.96 Lumen width, µm 34.28 Length/width ratio 63 Runkel ratio 0.289 Flexibility ratio 0.78 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.1 Solubility, % in water 1.8 in 1 % NaOH 8.0 Ash, % 0.4 Lignin, % 28.8 Holocellulose, % 48.8 Cross-Bevan cellulose, % 10.4 Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate (170°C)

20
25
47.6
0.4

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Jokro
x)
58.19
4.46
14.6

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

x) at sheet density 0.600 g/cm³

Scientific name: Pinus taeda L.	Common name: Loblolly pine Country: U.S.A.	References: 26
Wood sample characteristics		
<u>Wood sample origin:</u> Plantation 16 years <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 399 Fibre length, µm x) 2 870 Fibre width, µm 46.16 Wall thickness, µm 5.14 Lumen width, µm 35.87 Length/width ratio 62 Runkel ratio 0.290 Flexibility ratio 0.78 Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether 4.8 Methanol Ethanol-benzene Solubility, % in water 1.5 in 1 % NaOH 10.8 Ash, % 0.4 Lignin, % 27.9 Holocellulose, % Cross-Beyan cellulose, % 45.5 Pentosans, % 12.5 Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Sulphate (170°C)

20

23

42.0

0.4

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Jokro

x)

82.94

6.56

15.4

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information: x) at sheet density 0.600 g/cm³

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Sulphate (170°C)

30

45.2

PFI

575

80

7.0

15.2

Piptadenia communis

(Jacave)

Plantation experience

Piptadenia, with about 80 species, is abundantly represented in tropical South America, sparingly in tropical Africa and Asia and in New Guinea. The larger trees supply good timber of local utility, but their principal value is in the bark which is an important source of tanning material. Some species are planted for shade and decorative purposes in parks and along highways. The trees are at their best in northern Argentina and in Paraguay and Brazil.

References: 58

Wood characteristics

The species has very short fibres that are comparatively thin, but thick-walled.

Pulping characteristics

The wood requires a high alkali charge in sulphate cooking in order to arrive at acceptable levels of screenings. The pulp yield is low for a hardwood. The unbleached pulp exhibits strength characteristics similar to eucalypt pulp.

Scientific name: <i>Piptadenia communis</i>	Common name: Jacave Country: Brazil	References: 32
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Escola Superior de Florestas in Viscosa, Minas Gerais State <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 770 Fibre length, µm x) 18.2 Fibre width, µm 3.5 Wall thickness, µm 10.9 Lumen width, µm Length/width ratio 0.65 Runkel ratio 0.60 Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number x)
Yield (unscreened), %
Screenings, %

Sulphate
25 Na₂O (charge)
13.6
48.8
0.04

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

350 CSF
113
5.2
7.8

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

x) Permanganate Number

Piptadenia rigida

Plantation experience

The species is one of the best known *Piptadenia* species, generally considered to be the true Agnico of southern Brazil. See *Piptadenia communis*.

References: 58

Wood characteristics

The species has short fibres that are thin, but thick-walled.

Pulping characteristics

A high charge of alkali is required for sulphate cooking, and the pulp is obtained in comparatively low yield for a hardwood. The strength characteristics of the pulp resemble those of eucalypt pulp.

Scientific name: Piptadenia rigida	Common name: Country: Brazil	Reference: 32
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from the Escola Superior de Florestas in Viscosa, Minas Gerais State	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	Additional information:
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, μ m x) Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio	1 130 14.8 4.0 6.8 1.17 0.46	Additional information: x) 1000 μ m = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number x)

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

x) Permanganate Number

Sulphate

25 Na₂O (charge)

12.8

45.3

0.8

350 CSF

118

6.7

9.9

Populus deltoides
(Eastern Cottonwood)

Plantation experience

It is a North American species that flourishes in the upper parts of the Mississippi and Missouri valleys. The tree is often planted for windbreaks, shade and pulpwood in the U.S.A., but particularly in Argentina and Chile. The present sample is from the Parana river alluvials, and its growth is reported as higher than 20 m³/ha.a.

References: 57, 58, 67

Wood characteristics

This low-density wood has fibres of about average length for hardwoods. The fibre width seems normal. The lignin content is about normal for hardwoods.

Pulping characteristics

The refiner mechanical pulp made from the wood exhibits comparatively low strength values. Impregnation of the fibre material with sodium hydroxide at ambient temperature reduces the brightness, but increases the strength properties to acceptable levels.

Scientific name: <i>Populus deltoides</i> CV. 1 - 63/51	Common name: Alamocarolino mejorado Country: Argentina	References: 57
Wood sample characteristics		
<u>Wood sample origin:</u> Delta of Parana River 20 - 25 m ³ /ha.a <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 335 Fibre length, µm x) 1 034 Fibre width, µm 22.1 Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio 46.8 Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol 2.30 Ethanol-benzene Solubility, % in water 2.62 in 1 % NaOH 22.22 Ash, % 0.89 Lignin, % 23.72 Holocellulose, % 72.98 Cross-Bevan cellulose, % 56.41 Pentosans, % 20.11	Additional information: x) 1000 µm = 1mm

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Cold soda (25°C)
4 - 20 g NaOH/l

Mechanical

48 - 45

Bauer 606

65 SR

17 - 45

-

1.5 - 2.7

60

Sprout Waldron

65 SR

15.3

0.6

1.3

Populus X suramericana

Plantation experience

The present samples represent various poplar hybrids, all grown in the Parana river delta in Argentina. No detailed information of the hybrids is available. The growth is reported to exceed 20 m³/ha.a.

References: 57

Wood characteristics

The wood characteristics - density 350 kg/m³, fibre length about 1 mm and width 20 µm - are common for poplar species. The lignin content is also normal for hardwoods.

Pulping characteristics

The wood species have been tested as fibre sources for refiner mechanical pulp (RMP). According to the results, the RMP is of unacceptable strength, but by introduction of chemicals in the process the pulp strength can be improved considerably.

Scientific name:	Populus 3 species	Common name: Poplar	References: 25
		Country: Argentina	
Wood sample characteristics			
<u>Wood sample origin:</u> Delta of Parana River mean values for 3 species of poplar P. euramericana CV "1 - 154" P. euramericana CV "1 - 214" P. deltoides CV "1 - 63/51" <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 345 Fibre length, µm x) 1 038 Fibre width, µm 23 Wall thickness, µm Lumen width, µm Length/width ratio 45 Runkel ratio Flexibility ratio		<u>Chemical characteristics:</u> Extractives, % Ether 2.29 Methanol Ethanol-benzene Solubility, % in water 2.55 in 1 % NaOH 20.86 Ash, % 1.01 Lignin, % 23.06 Holocellulose, % 72.35 Cross-Beyan cellulose, % 58.28 Pentosans, % 19.6 Additional information:	
x) 1000 µm = 1mm		Additional information:	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

65 SR

17

-

1.5

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Mechanical

Scientific name: <i>Populus euroamericana</i> CV. 1 - 214	Common name: Alamo 214 Country: Argentina	Reference: 57
Wood sample characteristics		
<u>Wood sample origin:</u> Delta of Parana River 20 - 25 m ³ /ha.a <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 319 Fibre length, µm x) 994 Fibre width, µm 23.8 Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.33 Solubility, % in water 2.50 in 1 % NaOH 21.22 Ash, % 0.99 Lignin, % 23.21 Holocellulose, % 70.95 Cross-Bevan cellulose, % 58.35 Pentosans, % 19.85 Additional information:	Additional information:
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Mechanical

57

Sprout Waldron Bauer 606

65 SR

15.5

0.6

1.5

Scientific name: Populus euroamericana CV. 1 - 154	Common name: Alamo AM Country: Argentina	References: 57
Wood sample characteristics		
<u>Wood sample origin:</u> Delta of Parana River 20 - 25 m ³ /ha.a	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.23 Solubility, % in water in 1 % NaOH 2.52 19.14 Ash, % Lignin, % Holocellulose, % Cross-Beyan cellulose, % Pentosans, % 1.15 22.24 73.13 66.07 18.90	Additional information: x) 1000 μ m = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, μ m x) Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio 380 1 086 22.8 47.6	Additional information:	

Pulping and papermaking characteristics

<u>Unbleached</u>	
Process	
Chemical consumption, %	
Kappa number	
Yield (unscreened), %	
Screenings, %	
Brightness	53.5
Beater or refiner	
Freeness	65 SR
Tensile index, N m/g	17.20
Burst index, kPa m ² /g	0.7
Tear index, mN m ² /g	1.9
<u>Bleached</u>	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m ² /g	
Tear index, mN m ² /g	
Additional information:	

Gold soda (25°C)
4 - 20 g NaOH/l

41 - 33
Sprout Waldron 12" Bauer 606
65 SR
24 - 54
3.0 - 2.7

Salix alba

Plantation experience

The present sample is from Argentina. The stand density in the delta of Parana exceeded 1 000 trees/ha, and the capacity and growth were 200 m³/ha and more than 15 m³/ha. respectively.

References: 57

Wood characteristics

As far as wood density, fibre dimensions and lignin content are concerned, the samples exhibit values typical of hardwoods.

Pulping characteristics

The refiner mechanical pulp and the cold soda pulp exhibit typical for poplars and willows. The sulphate process using a low alkali charge gives pulp in low yiled and strength properties similar to those of beech pulp.

Scientific name: <i>Salix alba</i> var. <i>Calva</i>	Common name: Sauce alamo Country: Argentina	References: 57
Wood sample characteristics		
<u>Wood sample origin:</u> Delta of Parana River 1 650 - 1 100 plants/ha 180 - 230 m ³ /ha 15 - 20 m ³ /ha·a <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 404 Fibre length, µm x) 1 094 Fibre width, µm 22.3 Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio 49.1 Flexibility ratio	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 3.02 Solubility, % in water 3.50 in 1 % NaOH 19.96 Ash, % 0.99 Lignin, % 21.78 Holocellulose, % 75.13 Cross-Bevan cellulose, % 56.39 Pentosans, % 19.61 Additional informations:	Additional informations:
x) 1000 µm = 1mm		

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Cold soda (25°C)
4 - 20 g NaOH/l

Mechanical

51.6

Bauer 606

60 SR

17.8

0.7

2.3

65 SR

25 - 64

-

2.0 - 3.5

Salix X argentinensis
(Willow Hybrid)

Plantation experience

More than 200 species of *Salix* have been described, mostly of temperate regions, but ranging from the tropics to the arctic circle. They are chiefly shrubs and small poorly formed trees, but a few of them attain large dimensions. The pliable young shoots of some species are employed in making baskets and mats to protect river banks. They are often planted along streams and irrigation ditches to prevent erosion. The present samples of natural willow hybrids are from 200 m³/ha stands in the delta of Parana. The growth rate exceeds 15 m³/ha.a.

References: 57, 58

Wood characteristics

The wood density is comparatively low for a hardwood, and the fibre length about or slightly below average. The lignin content is relatively constant irrespective of hybrid, and about average for hardwoods.

Pulping characteristics

The strength characteristics of the refiner mechanical pulp are unsatisfactory, but treatment with sodium hydroxide at low temperatures or NSSC-pulping at high temperatures considerably improve these values.

<p>Scientific name: <i>Salix X argentinensis</i> ov. Hibrido <i>X salix alba A-114-1</i></p>	<p>Common name: Sauce A-114-1 Country: Argentina</p>	<p>Reference: 57</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u> Delta of Parana River 15 - 20 m³/ha.a</p>	<p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 295 Fibre length, µm x) 879 Fibre width, µm 18.0 Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether 2.71 Methanol Ethanol-benzene Solubility, % in water 3.48 in 1 % NaOH 20.35 Ash, % 0.83 Lignin, % 21.28 Holocellulose, % 74.76 Gross-Bevan cellulose, % 60.09 Pentosans, % 20.67</p> <p>Additional information:</p>
<p>x) 1000 µm = 1mm</p>		

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Brightness

Beater or refiner

Freeness

Tensile index, $N\ m/g$

Burst index, $kPa\ m^2/g$

Tear index, $mN\ m^2/g$

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, $N\ m/g$

Burst index, $kPa\ m^2/g$

Tear index, $mN\ m^2/g$

Additional information:

Mechanical	Cold soda (75°C)	NSSC (170°C)
45	45 - 28	25 - 50 $Na_2SO_3/1$
Sprout Waldron 12" Bauer 606	65 SR	43 - 40
65 SR	21 - 68	Bauer
11.5	1.0 - 4.0	65 SR
0.6	2.2 - 3.3	79.5 - 89.5
1.4		5.7 - 8.4
		3.5 - 3.8

<p>Scientific name: <i>Salix X argentinensis</i> cv. Híbrido</p>	<p>Common name: Sauce híbrido</p> <p>Country: Argentina</p>	<p>References: 57</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origins:</u> Delta of Paraná River 180 - 230 m³/ha 15 - 20 m³/ha·a natural hybrid</p> <p><u>Density and fibre characteristics:</u> Basic density, kg/m³ 370 Fibre length, µm x) 940 Fibre width, µm 25.8 Wall thickness, µm Lumen width, µm Length/width ratio Bunkal ratio Flexibility ratio</p> <p>Additional information: x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 3.23 Solubility, % in water 4.37 in 1 % NaOH 21.00 Ash, % 1.00 Lignin, % 22.16 Holocellulose, % 71.93 Cross-Bevan cellulose, % 57.14 Pentosans, % 20.86</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

45

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Sprout Waldron 12" Bauer 606

65 SR

20.27

0.8

2.4

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Mechanical

Scientific name: Salix X argentinensis cv. Mestizo	Common name: Sauce mestizo Country: Argentina	References: 57
Wood sample characteristics		
<u>Wood sample origin:</u> Delta of Parana River 180 - 230 m ³ /ha 15 - 20 m ³ /ha.a Natural hybrid	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, %	 <

Pulping and papermaking characteristics

Unbleached

Process

Chemical consumption, %

Kappa number

Yield (unscreened), %

Screenings, %

Brightness

50.8

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Sprout Waldron 12" Bauer 606

65 SR

17.69

0.7

2.4

Bleached

Sequence

Chemical consumption, %

Yield on bleaching, %

Total yield, %

Brightness

Beater or refiner

Freeness

Tensile index, N m/g

Burst index, kPa m²/g

Tear index, mN m²/g

Additional information:

Mechanical

Scientific name: <i>Salix X argentinensis</i> cv. <i>H. santafesino</i>	Common name: Hibrido Santafesino Country: Argentina	References: 57
Wood sample characteristics		
<u>Wood sample origin:</u> Delta of Parana River 180 - 230 m ³ /ha 15 - 20 m ³ /ha.a Natural hybrid	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 1.78 Solubility, % in water in 1 % NaOH 2.73 18.00 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 0.64 21.77 73.69 60.16 22.44	Additional information: x) 1000 µm = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio 362 962 21.0 46.1	Additional information:	

Pulping and papermaking characteristics

<u>Unbleached</u>	
Process	
Chemical consumption, %	
Kappa number	
Yield (unscreened), %	
Screenings, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, M m/g	
Burst index, kPa m ² /g	
Tear index, mN m ² /g	
<u>Bleached</u>	
Sequence	
Chemical consumption, %	
Yield on bleaching, %	
Total yield, %	
Brightness	
Beater or refiner	
Freeness	
Tensile index, M m/g	
Burst index, kPa m ² /g	
Tear index, mN m ² /g	
Additional information:	

NSSC (170°C)
 25 - 50 g Na₂SO₃/l

 Mechanical
 50
 43 - 40
 Sprout Waldron 12" Bauer 606
 60 SR
 13.60
 0.6
 1.7
 65 SR
 77.5 - 83.0
 5.2 - 5.6
 4.2 - 3.5

Salix babylonica var. sacramento
(Sauce Americano)

Plantation experience

The sample is taken from a 200 m³/ha stand in the delta of Parana. The growth rate exceeds 15 m³/ha.a.

References: 57

Wood characteristics

The wood density and the fibre length are higher than values normally found for willows; they are 450 kg/m³ and 1.3 mm respectively. The lignin content is in the range normal for hardwoods.

Pulping characteristics

The refiner mechanical pulp exhibits strength characteristics which are not quite up to standard. Treatment before refining with sodium hydroxide considerably improves the strength characteristics of the pulp to a very good level.

Scientific name: <i>Salix babylonica</i> var. <i>sacramento</i>	Common name: Sauce Americano Country: Argentina	Reference: 57
Wood sample characteristics		
<u>Wood sample origin:</u> Delta of Parana River 180 - 230 m ³ /ha 15 - 20 m ³ /ha.a	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene 2.75 Solubility, % in water in 1 % NaOH 3.19 18.37 Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % 0.84 22.53 71.03 56.66 18.83	Additional information: x) 1000 μ m = 1mm
<u>Density and fibre characteristics:</u> Basic density, kg/m ³ Fibre length, μ m x) Fibre width, μ m Wall thickness, μ m Lumen width, μ m Length/width ratio Runkel ratio Flexibility ratio 463 1 316 21.5 61.2	Additional information:	

Pulping and papermaking characteristics

<u>Unbleached</u>	
Process	
Chemical consumption, %	Cold soda (25°C)
Kappa number	4 - 20 g NaOH/l
Yield (unscreened), %	
Screenings, %	
Brightness	52
Beater or refiner	
Freeness	Sprout Waldron/Bauer 606
Tensile index, N m/g	65 SR
Burst index, kPa m ² /g	21.30
Tear index, mN m ² /g	0.8
	2.3
<u>Bleached</u>	
Sequence	
Chemical consumption, %	Bauer 606
Yield on bleaching, %	60 SR
Total yield, %	25 - 64
	-
	3.6 - 4.1
Brightness	
Beater or refiner	
Freeness	
Tensile index, N m/g	
Burst index, kPa m ² /g	
Tear index, mN m ² /g	
Additional information:	

Sesbania grandifolia

Plantation experience

The tree grows during 4.5 years up to above 10 m in height and over 200 mm in diameter at breast height, under irrigated plantation conditions. The present sample is from Australia.

References: 41

Wood characteristics

The medium-density wood contains average length fibres. No chemical characteristics are available for the present sample.

Pulping characteristics

Sulphate pulp has been obtained in comparatively low yield and its strength characteristics correspond roughly to those of beech sulphate pulp. The bleaching response is quite acceptable, but strength losses occur particularly as regards the tensile strength. NSSC pulping gives pulp with good strength characteristics.

Scientific name: <i>Sesbania grandifolia</i> Pers.	Common name: Country: Australia	Reference: 41
Wood sample characteristics		
<u>Wood sample origin:</u> Kimberley Research Station, Kununurra, W. (Order River Irrigation Area) Australia 4.5 years old trees from irrigated plantation Diameters (db) 20 - 33 cm Heights 10.8 - 12.9 m Butt,middle and top logs of 7 trees <u>Density and fibre characteristics:</u> Basic density, kg/m ³ 356 Fibre length, µm x) 1 140 Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: 15 - 19 % bark (by volume) of logs x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Crose-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

Sulphate
15 (charge)
21.1
46.3
0.4

NSSC
15 - 25% $\text{Na}_2\text{SO}_3 + 3.5 - 5.8\% \text{Na}_2\text{CO}_3$
(charge)
150 - 129
71 - 60
0

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, $\text{kPa m}^2/\text{g}$
Tear index, $\text{mN m}^2/\text{g}$

203 mm Bauer lab. refiner
300 CSF
50 - 70
-
6 - 7

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

CEHD
5.4 (% Cl in Cand H)
95.3
43.8

Brightness

88.7 % Elrepho

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, $\text{kPa m}^2/\text{g}$
Tear index, $\text{mN m}^2/\text{g}$

PFI
300 CSF
55
-
8

Additional information: Sulphidity 25%, 2 h at max.temp. 170°C 2 - 3 h at max.temp. 170 - 180°C

Terminalia brassii

Plantation experience

Terminalia, with about 200 named species of shrubs and medium-sized to very large trees, is of pantropical distribution. Numerous American forms of Terminalia are imperfectly known. Their combined range extends from the West Indies and Mexico to southern Brazil and northern Argentina. The trees are often tall and well formed. The timber is of good quality, but it is not extensively used.

References: 22, 58

Wood characteristics

The wood is of low density. Fibre dimensions and the lignin content of the wood sample are not reported.

Pulping characteristics

The sulphate cook gives normal yield at suitable Kappa number levels. The pulp yield is low for hardwood sulphate pulps. The chemical charge is quite normal for hardwoods. The strength characteristics of the pulp are similar to Scandinavian birch pulp.

Scientific name: Terminalia brassii	Common name: Country: Papua New Guinea	Reference: 56
Wood sample characteristics		
<u>Wood sample origin:</u> Sample from Keravat, New Britain a) 4, b) 6 and c) 9 year old <u>Density and fibre characteristics:</u> Basic density, kg/m ³ a) 302 b) 267 c) 287 Fibre length, µm x) Fibre width, µm Wall thickness, µm Lumen width, µm Length/width ratio Runkel ratio Flexibility ratio Additional information: x) 1000 µm = 1mm	<u>Chemical characteristics:</u> Extractives, % Ether Methanol Ethanol-benzene Solubility, % in water in 1 % NaOH Ash, % Lignin, % Holocellulose, % Cross-Bevan cellulose, % Pentosans, % Additional information:	

Pulping and papermaking characteristics

Unbleached

Process
Chemical consumption, %
Kappa number
Yield (unscreened), %
Screenings, %

a
Sulphate
16 x)
22.4
48.0
0.3

b
Sulphate
16 x)
19.4
48.5
0.1

c
Sulphate
16 x)
19.5
48.5
-

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

PFI
300 CSF
135
9.6

PFI
300 CSF
135
7.8

PFI
300 CSF
135
8.9

Bleached

Sequence
Chemical consumption, %
Yield on bleaching, %
Total yield, %

Brightness

Beater or refiner
Freeness
Tensile index, N m/g
Burst index, kPa m²/g
Tear index, mN m²/g

Additional information:

x) Total alkali charge as Na₂O

<p>Scientific name: <i>Terminalia brassii</i></p>	<p>Common name:</p> <p>Country: Solomon Island</p>	<p>Reference: 22</p>
<p>Wood sample characteristics</p>		
<p><u>Wood sample origin:</u></p> <p>Sample from trees a) 30 and b) 12 years old</p> <p><u>Density and fibre characteristics:</u></p> <p>Basic density, kg/m³ a) 325 b) 370</p> <p>Fibre length, µm x)</p> <p>Fibre width, µm</p> <p>Wall thickness, µm</p> <p>Lumen width, µm</p> <p>Length/width ratio</p> <p>Runkel ratio</p> <p>Flexibility ratio</p> <p>Additional information:</p> <p>x) 1000 µm = 1mm</p>	<p><u>Chemical characteristics:</u></p> <p>Extractives, %</p> <p> Ether</p> <p> Methanol</p> <p> Ethanol-benzene</p> <p>Solubility, %</p> <p> in water</p> <p> in 1 % NaOH</p> <p>Ash, %</p> <p>Lignin, %</p> <p>Holocellulose, %</p> <p>Cross-Beyan cellulose, %</p> <p>Pentosans, %</p> <p>Additional information:</p>	

Pulping and papermaking characteristics

<u>Unbleached</u>	<u>a</u>	<u>b</u>
Process	Sulphate	Sulphate
Chemical consumption, %	16 %	16 %
Kappa number	36.3	33.4
Yield (unscreened), %	48.0	49.3
Screenings, %	0.1	0.7
Brightness		
Beater or refiner	PFI	PFI
Freeness	205	220
Tensile index, N m/g	95	95
Burst index, kPa m ² /g	8	9
Tear index, mN m ² /g	13	13
<u>Bleached</u>		
Sequence		
Chemical consumption, %		
Yield on bleaching, %		
Total yield, %		
Brightness		
Beater or refiner		
Freeness		
Tensile index, N m/g		
Burst index, kPa m ² /g		
Tear index, mN m ² /g		
Additional information:		

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Appendix II

DEFINITION OF TERMS USED

I. Wood sample characteristics

Basic density	The ratio of oven dry weight of the sample to its green (wet) volume.
Runkel ratio	2 x fibre wall thickness/fibre width
Flexibility ratio	Lumen width/fibre width
Holocellulose	The residue after extraction and delignification, either with chlorine or chlorite. It is supposed to represent the total content of carbohydrates in the wood - cellulose + hemicellulose (non-cellulosic carbohydrates) - but usually some carbohydrates are lost during the delignification treatment and some lignin is retained.
Cross-Bevan cellulose	The residue in percent of oven dry wood after treatment with a succession of chlorine, sulphur dioxide water, sodium sulphite and a 17.5% solution of sodium hydroxide. It is an approximation of the cellulose content of the wood but can sometimes be seriously in error.

II. Pulping and Paper-making Characteristics

II.1. Unbleached

Processes:

Sulphate	A process for digestion of the wood with sodium hydroxide and sodium sulphide as chemicals at temperatures between 150°C and 170°C. The pulp obtained with a very low charge of chemicals and at high yield is called crude sulphate pulp.
Chemical soda	A process of digestion of the wood with sodium hydroxide alone as cooking chemical at temperatures between 90°C and 170°C.

Cold soda	A chemi-mechanical or semi-mechanical process where the wood is impregnated with sodium hydroxide at ambient temperature and thereafter given a mechanical treatment in order to obtain defibration of the chips.
NSSC	A semi-chemical process, Neutral Sulphite Semi-Chemical, and as the name suggests, it comprises treatment of the wood chips with a sodium sulphite solution with an addition of sodium carbonate in order to arrive at neutral or slightly alkaline conditions. This treatment is carried out at elevated temperatures and followed by mechanical treatment.
Sodium bisulphite	A semi-chemical or chemical process with sodium bisulphite as cooking chemical is carried out at slightly acid conditions. The temperature range is usually 130-160°C. If the yield is left high, a mechanical treatment is given as a second stage (semi-chemical or high-yield bisulphite pulp).
Groundwood	A mechanical pulping process where defibration is achieved by grinding wood billets on a stone grinder.
Refiner mechanical pulp (RMP)	A mechanical pulping process where defibration of the chips is obtained by means of refining in disc refiners.
Thermomechanical pulp (TMP, CTMP)	See "RMP". The refining is made at elevated temperatures (TMP). Chemical treatment at low temperatures followed by refining at elevated temperatures (CTMP).
Chemical consumption	The consumption of chemicals in the process expressed as percent of oven dry wood.
Kappa number	The consumption of a 0.1 N potassium permanganate solution by 1 g of pulp, under specified conditions and expressed as the consumption in ml corresponding to 50% consumption of the volume of solution added. It is a direct measure of the content of residual lignin in the pulp.
Yield (unscreened)	The yield of pulp in the process, expressed in percent of oven dry wood.

Screenings The amount of shives and knots in the pulp retained by a screen and expressed in percent of oven dry wood.

Brightness The brightness of a sheet of pulp, measured under specified conditions with a blue filter (457 nm) and expressed as reflection factor with smoked magnesium oxide as 100.

Freeness Also called "wetness" or "degree of beating" it expresses how extensive the beating or refining treatment has been. Two scales are applied in this context:
a) the Canadian Standard Freeness (CSF) with a graduation from 1 000 to 0 and
b) the Schopper Riegler (SR) value with a graduation from 0 to 100. They are not linearly related. The following table gives a rough comparison of the two scales:

CSF	SR
700	15
600	20
500	25
400	32
300	40
200	52
100	68

Tensile index A measure of the tensile strength of the paper under standard conditions (conversion factor from breaking length in m to tensile index in $\text{N.m/g} \approx 0.01$).

Burst index A measure of the pressure at which the paper will burst as determined under standard conditions (conversion factor from burst factor to burst index in $\text{kPa.m}^2/\text{g} \approx 0.1$).

Tear index A measure of the tearing resistance of the paper under standard conditions of test (conversion factor from tear factor to tear index in $\text{mN.m}^2/\text{g} \approx 0.1$).

II.2 Bleached

Sequence A description of the stages of bleaching applied to the pulp. The following abbreviations are used:

C Chlorination
E Extraction with sodium hydroxide
H Hypochlorite treatment
D Chlorine dioxide treatment
P Peroxide treatment
HS Hydrosulphite (dithionite) treatment

Yield on bleaching	The yield on bleaching expressed in percent of unbleached pulp.
Total yield on bleaching	The total yield of pulp after bleaching, expressed in percent of oven dry wood.
Brightness	See "Unbleached"
Freeness	See "Unbleached"
Tensile index	See "Unbleached"
Burst index	See "Unbleached"
Tear index	See "Unbleached"

Appendix III

LIST OF SPECIES EVALUATED FOR PULPING CHARACTERISTICS

<u>Species</u>	<u>Page</u>
<i>Acacia auriculaeformis</i>	7
<i>Acacia decurrens</i>	11
<i>Acacia mollissima</i>	17
<i>Albissia falcata</i>	21
<i>Ammona sericeae</i>	27
<i>Anthocephalus cadamba</i>	31
<i>Anthocephalus chinensis</i> (see <i>Anthocephalus cadamba</i>)	31
<i>Aquilaria agallocha</i>	41
<i>Araucaria angustifolia</i>	45
 <i>Bursera simaruba</i>	 49
 <i>Cedrus atlantica</i>	 53
<i>Cupressus lusitanica</i>	57
 <i>Eucalyptus alba</i>	 61
<i>Eucalyptus calophylla</i>	67
<i>Eucalyptus camaldulensis</i>	73
<i>Eucalyptus citriodora</i>	79
<i>Eucalyptus cloeziana</i>	83
<i>Eucalyptus cypellocarpa</i>	87
<i>Eucalyptus deanei</i>	91
<i>Eucalyptus deglupta</i>	97
<i>Eucalyptus diversicolor</i>	103
<i>Eucalyptus dunni</i>	109
<i>Eucalyptus fastigata</i>	113
<i>Eucalyptus globulus</i>	117
<i>Eucalyptus grandis</i>	127
<i>Eucalyptus macarthurii</i>	143
<i>Eucalyptus maculata</i>	147
<i>Eucalyptus maidenii</i>	153
<i>Eucalyptus marginata</i>	157
<i>Eucalyptus naidiana</i> (see <i>Eucalyptus deglupta</i>)	97
<i>Eucalyptus nitens</i>	161
<i>Eucalyptus ovata</i>	165
<i>Eucalyptus paniculata</i>	169
<i>Eucalyptus regnans</i>	173
<i>Eucalyptus robusta</i>	183
<i>Eucalyptus rostrata</i> (see <i>Eucalyptus camaldulensis</i>)	73

<u>Species</u>	404	<u>Page</u>
<i>Paulownia fortunei</i>		247
<i>Pinus caribaea</i>		251
<i>Pinus elliotii</i>		267
<i>Pinus halepensis</i>		281
<i>Pinus insignis</i> (see <i>Pinus radiata</i>)		217
<i>Pinus insularis</i> (see <i>Pinus kesiya</i>)		285
<i>Pinus kesiya</i>		289
<i>Pinus merkusii</i>		295
<i>Pinus oocarpa</i>		301
<i>Pinus patula</i>		307
<i>Pinus radiata</i>		317
<i>Pinus taeda</i>		329
<i>Piptadenia communis</i>		337
<i>Piptadenia rigida</i>		341
<i>Populus deltoides</i>		345
<i>Populus x euramericana</i>		347
<i>Salix alba</i>		357
<i>Salix x argentinensis</i>		361
<i>Salix babylonica</i> var. <i>sacramento</i>		371
<i>Sesbania grandifolia</i>		375
<i>Terminalia brassii</i>		379

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